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ZINC CONTENT OF HUMAN CANCELLOUS BONE

E M ALHAVA, H OLKKONEN, J PUITTINEN & V-M NOKSO-KOIVISTO

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The zinc content of cancellous bone from the iliac crest was determined by the X ray fluorescence technique in an autopsy series of 28 women and 66 men The bone zinc content was statistically related to age, but there was a large variation It reached a maximum value in the fifth decade and thereafter decreased with age in both sexes Men with a chronic disease had a lower zinc content than those who had died suddenly There was a significant correlation between the zinc content and the bone strength in women ($p < 0.01$) and in men ($p < 0.05$) Zinc is thought to play a part in osteoporosis

Key words zinc bone and bones, osteoporosis, bone strength

Accepted 20 x 76

Zinc is one of the most abundant of the essential trace elements in the human body It has been reported to exert an effect upon enzymes and enzymatic function (Mikac-Dević 1970), protein synthesis (Fujioka & Lieberman 1964), carbohydrate metabolism (Mikac Dević 1970) and bone formation (Haumont & McLean 1966) Quite a lot is known about the zinc content of the skeleton, but we know little about any changes in osteoporosis or bone fragility (Aitken 1976)

The purpose of the present investigation was to study the zinc content in the cancellous bone of the iliac crest with regard to age, sex, disease, bone strength and mineral density

MATERIAL

Two bone specimens were taken post mortem from the anterior iliac crests of 28 women and 66 men both urban and rural dwellers in the central hospital district of Kuopio One of the specimens was macerated and the other was fixed in 40 per cent ethyl alcohol The age and sex distribution is shown in Figure 1 Fourteen of the women and 45 of the men had died suddenly from acute coronary artery disease or accidents The remaining 14 women and 21 men had died from chronic immobilizing diseases

METHODS

a) *Macerated specimen*

The sample was placed in a 5 per cent solution of sodium hypochlorite until the soft organic tissues were destroyed It was then washed carefully with water, and then incubated at 20° C in 5 per cent sodium bicarbonate for 48 hours and re washed with water The sample was then left in 5 per cent hydrogen peroxide for 48 hours and washed again Residual fat was removed from the dry sample with xylene (72 hours)

The area of the iliac crest was measured by the ^{238}Pu excited semiconductor detector X-ray fluorescence analysis (Patomaki & Olkkonen 1974, Olkkonen et al 1976) The area of the zinc $K\alpha$ X ray peak (8 6 keV) was calibrated by adding different amounts of internal standard ($ZnCl_2$) to a series of ten samples The reproducibility of the method was tested in ten samples from the

bone material containing 50 $\mu g/g$ of zinc The coefficient of variation was 3 5 per cent

b) *Fixed specimen*

A strain-transducer (Nokso-Koivisto et al 1976) was used for measurements of the compressive strength of trabecular bone The diameter of the measuring pin was 3 0 mm The result was expressed as the mean of three measuring values obtained at different locations on the cut surface of the specimen

Bone-mineral density was determined using a modification of the gamma ray attenuation method presented by Karjalainen (1973)

RESULTS

The zinc content of dry fat-free cancellous bone showed large distributions in both sexes as a function of age (Figure 1) The second-degree regression curves fitted to the distributions show that zinc concentration reaches its statistical maximum in the fifth decade in both sexes and thereafter decreases with age Males with a chronic disease had a significantly lower zinc content than those who died suddenly ($p < 0\ 01$, t-test)

Both the bone strength and mineral-density distributions showed a significant ($p < 0\ 01$) decrease with age after the age of 30 in both sexes

Bone strength correlated highly significantly with the mineral density of cancellous bone both in females ($r = 0\ 59$, $p < 0\ 001$) and in males ($r = 0\ 65$, $p < 0\ 001$)

Correlations of the zinc content with bone-compressive strength and age are summarized in Table 1 In the statistical analysis of the results for a linear correlation with the zinc concentration, bone strength and age, bones under 30 years of age, that is, those in the ascending part of the parabolic zinc distribution, were excluded The zinc concentration correlated significantly with the bone strength in females and in the whole male group The correlation was also significant for the male cases of sudden death, but not for deaths due to chronic disease The

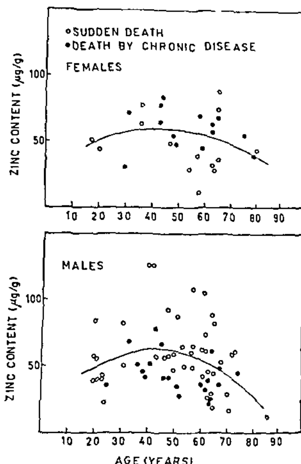


Figure 1 Distribution of the zinc content of dry fat free cancellous bone according to age

Table 1 Correlations of the zinc content of cancellous bone with strength and age in groups ≧30 years of age

	Strength	Age
Females (Total 26)	$r = 0\ 48$ $p < 0\ 01$	$r = -0\ 37$ $p < 0\ 05$
Males (Total, 57)	$r = 0\ 33$ $p < 0\ 05$	$r = -0\ 34$ $p < 0\ 01$
Males (Sudden deaths 36)	$r = 0\ 40$ $p < 0\ 01$	$r = \ 0\ 47$ $p < 0\ 01$
Males (Deaths from chronic disease, 21)	$r = 0\ 23$ N S	$r = -0\ 36$ N S

N S = not significant

zinc content was significantly related to age in females, in the whole male group and male sudden deaths On the other hand, males with chronic disease had a

zinc content which was not correlated with their age

DISCUSSION

There is loss of bone mineral in chronic diseases which cause physical inactivity. We assume that our rough division of patients into cases of sudden death and chronic immobilizing diseases would separate osteoporotics from those with a normal mineral status. We used the area of iliac cancellous bone for the present study because metabolic changes are more detectable in trabecular than in cortical bone (Frost 1966). Moreover, in clinical work histopathological studies are usually performed from the iliac bone biopsies. Our strain transducer is also constructed to measure the trabecular bone strength. We made the measurements at the cancellous bone area on the cut surface of iliac bone as far as possible from the periosteal borders. The determination of zinc by X-ray fluorescence is highly sensitive but we have not found any reports on the use of this method for the measurement of bone zinc. The zinc values obtained in this work were between the values previously reported for bone ash and fresh weight (Calhoun et al 1974). Close comparisons are difficult because of different pre-treatment procedures.

There are a number of studies of the zinc concentration in human bone (Nusbaum et al 1965, Becker et al 1968, Strehlow & Kneip 1969, Spadaro & Becker 1970, McBean et al 1972, Aitken 1976). Becker's group studied the trace elements of archaeological and modern bones and reported that the zinc content was the same in old and newer bones. McBean et al (1972) studied 30 adult subjects at necropsy. They divided the group into two categories: accidental deaths (controls) and deaths due to disease. Analysis of the bone did not reveal any statistically significant difference between the mean zinc concentrations in these two groups. In our study, men with a chronic disease had a lower zinc content than those who had died suddenly. Patients with diabetes, malignant disease or coronary artery disease did not differ from the others in their bone-zinc content. This may be due to the relatively small number of patients in these groups.

Aitken (1976) showed a progressive increase with age in the bone zinc content relative to calcium. We found an increase in our study up to the age of about 40, and thereafter a decrease in the zinc content of dry fat free cancellous bone. Schroeder et al (1967) showed a similar pattern of distribution with age in the zinc content of kidney as we did in bone.

Bone strength is generally correlated with the bone-mineral content (Bartley et al 1966, Nokso-Koivisto et al 1976). In our work it was not possible to compare the zinc concentration with mineral density because they were expressed in non-equivalent units of $\mu g/g$ and g/cm^3. The zinc concentration of cancellous bone was related to bone strength. It is difficult to explain what part collagen and what part mineral play in the strength of bone.

In osteoporosis the basic abnormality is imbalance between bone resorption and apposition. Zinc is needed in bone formation especially in matrix (Bergman et al 1972). It is also evident from animal tests that extremely high dietary concentrations of zinc decrease the total ash content of bone (Huxley & Leaver 1966). Hence the relationship of zinc to bone mineral is complicated.

In conclusion we can state that the zinc content of bone is related to age and bone strength. The role of zinc in osteoporosis is obscure and requires further studies.

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SERUM ELECTROPHORETIC PATTERN IN OSTEOARTICULAR TUBERCULOSIS

G C PRASAD, K BALDEV, P K SHUKLA & P J DESHPANDE

Department of Shalya Shalakya & Department of Pathology Institute of Medical Sciences Banaras Hindu University, Varanasi India

A serum electrophoretic study was carried out in 37 established osteoarticular tuberculosis cases The result of this study has been analysed according to severity and chronicity and also after treatment including certain streptomycin resistant cases It has been observed that there was a decrease in albumin and an increase in $Alpha_2$ and gamma globulin fractions of serum protein as the disease became more advanced and chronic in nature The administration of known antitubercular drugs reverses this phenomenon The resistant cases revealed an increase in gamma globulin fraction at almost the same level as observed in the untreated cases

Key words tuberculosis serum electrophoresis

Accepted 7 x 76

In spite of a good regimen of chemotherapy tubercular infection may persist in some osteoarticular lesions for a number of months (Debaumont 1966) This raises the question that it might be developing resistance to the standard antitubercular therapy However, there are no parameters available by which one can exclude those cases that are acquiring resistance to streptomycin therapy Moreover there are very few criteria through which the effectiveness of any therapeutic trial can be assessed

It is a well established phenomenon that patients with tuberculosis invariably become hypoproteinaemic due to undernourishment Under the circumstances variations in different fractions of protein are known to occur both quantitatively and qualitatively, and these conditions are referred to as paraproteinaemia and disproteinaemia respectively This alteration of different protein fractions has been demonstrated in various other diseases such as Kala azar nephrotic syndrome and pulmonary tuberculosis (Narsimha & Sadasivudu 1964) However, no reports are available where the protein fractions in skeletal tubercular cases have been studied

PATIENTS AND METHOD

We studied 57 cases 20 were normal and 37 were suffering from osteoarticular tuberculosis Out of the 37 cases of oste[illegible] there [illegible] (e g [illegible] plegia [illegible] control etc) Twenty one were male and 16 were female All cases were in different age groups ranging from 14 to 45 years The diagnosis was established by

(1) Clinical examination

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PATIENTS AND METHOD

We studied 57 cases 20 were normal and 37 were suffering from osteoarticular tuberculosis Out of the 37 cases of osteoarticular tuberculosis there were five with neurological complications (e g tingling sensation in the lower limb para plegia loss of urinary bladder control etc) Twenty one were male and 16 were female All cases were in different age groups ranging from 14 to 45 years The diagnosis was established by

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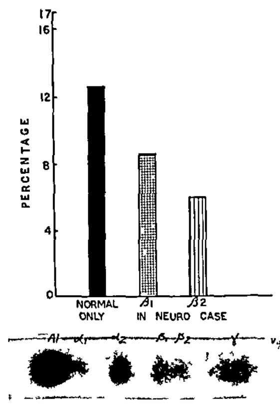


Figure 1 The extra Beta$_2$ band in serum electrophoretic strip in the cases of Pott's spine with neurological complications

(3) Mantoux test
(4) Erythrocyte sedimentation rate

Then a blood sample was taken from each patient for serum electrophoretic study After fixation and staining of the filter paper strips, each fraction of protein was eluded by calorimetric readings for quantitative estimation

The levels of Albumin Alpha$_1$, Alpha Beta and Gamma fractions of serum protein were analysed according to the severity and chronicity of the disease The electrophoretic analysis of protein was repeated after two and four months of the standard regimen of antitubercular treatment For analysis according to chronicity the cases were divided into three main groups

(a) Those having the lesion for up to six months
(b) Seven months to one year
(c) More than one year

Similarly, these cases were also divided into three grades depending on the severity of the disease i e, Grades I, II and III

RESULTS

Results of this study on 37 patients were analysed according to the grades and chronicity In addition, the normal values of 20 individuals were compared with the normal values reported in the literature

Serum electrophoretic pattern according to grades

It has been observed that there was a gradual decline in the level of serum albumin fraction as the disease advanced from Grade I to Grade III, in comparison with the normal values (Table 1) An

Table 1 Serum protein analysis according to grades

Grade	Albumin % Range	Albumin % Mean	Globulin Alpha$_1$ % Range	Alpha$_1$ % Mean	Alpha$_2$ % Range	Alpha$_2$ % Mean	Beta % Range	Beta % Mean	Gamma % Range	Gamma % Mean
I	37 12 49 71	44 92	3 55 7 52	5 60	8 09 11 78	10 43	12 72 19 24	16 24	20 29 2(16	22 81
II	36 10 51 07	43 35	4 74 9 30	6 65	7 93 15 32	11 (3	10 17 17 51	14 17	20 46 2(27	23 90
III	24 05 46 39	30 58	1 41 7 27	4 90	8 89 22 2	14 38	10 03 20 00	10 34	21 22 48 90	29 80
Normal		52 87		5 19		9 04		12 (4		20 2(

Table 2 According to chronicity

Chronicity	Albumin %		Globulin Alpha$_1$ %		Alpha$_2$ %		Beta %		Gamma %	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Up to 6 months	20 55 47 70	34 11	3 10 11 64	5 55	7 62 18 06	13 86	8 33 17 38	13 86	20 46 39.37	32 62
6 months to 1 year	25 33 51 31	43.25	2 72 7 51	4 98	7.31 22 20	12 70	10 50 19 25	14 31	19.31 29 33	24 86
1 to 2 years	24 05 47 94	33 90	2 74 7 27	4 74	9 59 15 15	11 31	10 77 20 00	14 43	30 29 48 71	35 73

estimate of the Alpha$_1$ fraction showed a gradual increase in Grade I and also in Grade II followed by a small decrease in Grade III whereas the other globulin fraction, i e, Alpha$_2$, revealed a gradual increase in the level as the disease advanced from Grade I to III The gamma fraction of serum globulin showed an increase in the level as the disease advanced from Grade I to Grade III (Table 1)

Serum electrophoretic pattern according to chronicity

Analysis of the albumin fraction of serum protein showed a decrease in the concentration as the disease became more and more chronic in nature The Alpha$_1$ and Alpha$_2$ fractions of serum protein did not reveal much difference in comparison with the normal level Similarly the Beta fraction was on a higher level throughout the period with little change according to the chronicity The most important observation made in connection with the chronicity was in the level of the gamma fraction of serum globulin The level of gamma globulin *increased* as the disease became chronic in nature (Table 2)

Pott s spine with neurological complications

In this series we have included only those three paraplegic cases who had lost their control of the urinary bladder and anal sphincters Significant observations made in all these cases were that there was an extra band of Beta fraction of serum globulin This was labelled as Beta$_2$ fraction (Figure 1) The Beta fraction of serum protein also showed a much lower value in comparison with those cases of osteoarticular tuberculosis without neurological complications However, the total value of Beta fraction (Beta$_1$ and Beta$_2$) in these cases was almost the same as in the uncomplicated cases Also the values of other protein fractions were almost the same as observed in the uncomplicated cases

Effect of operation

The electrophoretic analysis of serum proteins in these paraplegic cases was repeated two months later after operative intervention It was observed that the extra band of the Beta fraction of globulin had disappeared without much change in the Beta$_1$ fraction The albumin fraction increased to 51 61 per cent from a previous value of 47 19 per cent, whereas the gamma globulin fraction of protein decreased from 25 65 per cent to 19 48 per cent two months after operation

Effect of antitubercular treatment

Those cases treated with standard antitubercular therapy (Streptomycin 1 g,

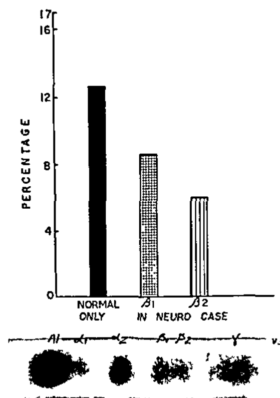


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II	36 10 51 07	43 35	4 74 9 30	6 C5	7 93 15 32	11 63	10 17 17 51	14 47	20 4C 2C 27	23 90
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Effect of antitubercular treatment

Those cases treated with standard antitubercular therapy (Streptomycin 1 g,

Table 3 Serum protein analysis after antitubercular treatment

Treatment	Albumin %		Globulin							
			Alpha$_1$ %		Alpha$_2$ %		Beta %		Gamma %	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Before	28 05 43 02	34 88	3 58 7 93	5 41	7 85 17 68	12 77	8 75 15 68	12 11	29 65 39 37	34 83
After 2 months	35 12 51 27	42 07	1 66 9 92	4 74	7 96 15 28	11 67	5 35 15 93	11 03	21 17 34 32	30 50
After	46 36 54 84	47 70	4 03 7 27	5 65	11 29 15 15	11 22	12 10 20 00	16 05	17 74 21 21	19 38

Isonex 300 mg, and P A S 6 g daily for two months) showed a gradual increase in the albumin fraction of serum protein at different intervals during follow-up The Alpha$_1$ and Beta fractions of serum globulin did not reveal any significant change during treatment, whereas the Alpha$_2$ decreased in the subsequent follow-up The gamma-globulin fraction which was higher before starting the treatment showed a rapid fall in concentration during treatment (Table 3)

Serum electrophoretic pattern in streptomycin-resistant cases

In this series we have included those cases who had full antitubercular treatment for two months or more, but had produced no beneficial effect The electrophoretic study of serum protein in these cases revealed a decrease in the albumin fraction and a significant increase in the gamma-globulin fraction, which was almost at the same level as those who had no previous antitubercular treatment Remaining fractions, i e, Alpha$_1$, Alpha and Beta did not show much difference

DISCUSSION

Seibert et al (1947) were probably the first to report the serum electrophoretic pattern in pulmonary tuberculosis cases Their investigations showed an increase in Alpha and gamma-globulin fractions in the early stage of tuberculosis They have further pointed out that in chronic illness all the globulin fractions tend to be raised Narsimha & Sadasivudu (1964) have also observed a high gamma globulin and a decrease in albumin fraction in pulmonary tuberculosis, which was confirmed by the work of Blokhin & Syromyatnikova (1964) However, none of these workers have studied the electrophoretic pattern at the various stages of skeletal tuberculosis nor have they correlated the response of antitubercular treatment

The results of our study, when classified according to the grade and chronicity of osteoarticular tuberculosis cases, indicate that the Alpha_ fraction of serum globulin increases gradually as the disease becomes more advanced and chronic in nature The increase in serum gamma globulin corroborates the observation by Schaffner et al (1953) who attributed the increase in gamma globulin to immunological factors It suggests that as this disease becomes more and more advanced, there is more demand for antibody production in the body Since the main function of the plasma proteins particularly of the albumin fraction, is the maintenance of plasma-osmotic pressure the decrease in the level of this fraction

in the serum suggests that it is probably due to undernourishment of the tissue in these cases Our study also suggests that by measuring the albumin, Alpha and gamma globulin fractions of serum protein the severity of the disease can be determined

A similar observation was made in the cases of Pott s spine with neurological complications when an extra band of $Beta_2$ globulin was observed This disappeared after compression was relieved It is very difficult to interpret this extra Beta fraction of serum protein at this stage although it was a constant finding However it may be possible that this extra band is due to compression over the spinal cord

Those skeletal tuberculosis cases treated with standard antitubercular therapy showed a fall in gamma globulin fraction of serum protein after 2 to 4 months of treatment in comparison with the pretreatment value Whereas the albumin fraction had a decreasing tendency in the early stages it started increasing to reach a normal level after treatment This confirms our findings that raised gamma globulin and decreased albumin occurs in tubercular cases that have responded to the antitubercular treatment Thus these values could be taken as one of the main quantitative criteria for assessing the effectiveness or the extent of the lesion and response to any antitubercular drugs

Some of the established osteoarticular tuberculosis cases did not respond to the antitubercular treatment In these cases gamma globulin fraction was found to be raised even after treatment These studies suggest that probably by measuring the albumin and gamma globulin fraction of serum protein one may find out whether the disease is responding to antitubercular therapy, or becoming resistant to streptomycin, even in the early stages

ACKNOWLEDGEMENT

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DISCUSSION

Seibert et al (1947) were probably the first to report the serum electrophoretic pattern in pulmonary tuberculosis cases Their investigations showed an increase in $Alpha_2$ and gamma-globulin fractions in the early stage of tuberculosis They have further pointed out that in chronic illness all the globulin fractions tend to be raised Narsimha & Sadasivudu (1964) have also observed a high gamma globulin and a decrease in albumin fraction in pulmonary tuberculosis, which was confirmed by the work of Blokhin & Syromyatnikova (1964) However, none of these workers have studied the electrophoretic pattern at the various stages of skeletal tuberculosis nor have they correlated the response of antitubercular treatment

The results of our study, when classified according to the grade and chronicity of osteoarticular tuberculosis cases, indicate that the Alpha fraction of serum globulin increases gradually as the disease becomes more advanced and chronic in nature The increase in serum gamma globulin corroborates the observation by Schaffner et al (1953) who attributed the increase in gamma globulin to immunological factors It suggests that as this disease becomes more and more advanced there is more demand for antibody production in the body Since the main function of the plasma proteins particularly of the albumin fraction, is the maintenance of plasma osmotic pressure, the decrease in the level of this fraction

in the serum suggests that it is probably due to undernourishment of the tissue in these cases Our study also suggests that by measuring the albumin Alpha and gamma globulin fractions of serum protein the severity of the disease can be determined

A similar observation was made in the cases of Pott s spine with neurological complications when an extra band of Beta globulin was observed This disappeared after compression was relieved It is very difficult to interpret this extra Beta fraction of serum protein at this stage although it was a constant finding However it may be possible that this extra band is due to compression over the spinal cord

Those skeletal tuberculosis cases treated with standard antitubercular therapy showed a fall in gamma globulin fraction of serum protein after 2 to 4 months of treatment in comparison with the pre treatment value Whereas the albumin fraction had a decreasing tendency in the early stages it started increasing to reach a normal level after treatment This confirms our findings that raised gamma globulin and decreased albumin occurs in tubercular cases that have responded to the antitubercular treatment Thus these values could be taken as one of the main qualitative criteria for assessing the effectiveness or the extent of the lesion and response to any antitubercular drugs

Some of the established osteoarticular tuberculosis cases did not respond to the antitubercular treatment In these cases gamma globulin fraction was found to be raised even after treatment These studies suggest that probably by measuring the albumin and gamma globulin fraction of serum protein one may find out whether the disease is responding to antitubercular therapy or becoming resistant to streptomycin even in the early stages

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MUSCLE BLOOD FLOW AFTER AMPUTATION WITH SPECIAL REFERENCE TO THE INFLUENCE OF THE AMPUTATION LEVEL

Assessed by 133 Xenon and Histamine

An Animal Experiment

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Amputation on rabbits was found to change the muscle blood flow (MBF) in the limb subjected to surgery as well as in the contralateral extremity, depending on the technique used for amputation and the level at which it was carried out Amputation was immediately followed by a reduction in MBF in the stump After amputation of the crus and knee disarticulation the flow was normalized a few days later and exceeded the preoperative mean flow After amputation of the femur such an increase in flow was not seen but when osseous plugging of the medullary cavity was applied the MBF in the stump was intensified even after amputation of the femur

Key words amputation, knee disarticulation, medullary plugging, muscle blood flow, myoplasty, 133 Xenon-clearance method

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In a previous study (Hansen-Leth 1976) it was demonstrated that assessment of the muscle blood flow (MBF) by 133 Xenon and Histamine (Lindbjerg 1965) was a valuable means of evaluating the vascular changes in rabbits undergoing amputation After amputation of the crus, an increased MBF was found in the amputation stump if the stump was closed by myoplasty the flow was intensified and osseous plugging of the medullary cavity resulted in a further increase in MBF

In this study MBF was measured after amputation of the crus and femur in order to investigate the influence of the amputation level Furthermore, amputation with myoplasty and osseous plugging of the medullary cavity was compared with knee disarticulation in order to establish whether MBF might be influenced by surgery on muscle and bone

MATERIAL AND METHOD

Twenty one adult rabbits were subjected to amputation of the left hind leg In nine cases amputation was performed on the crus in six cases on a proximal site at the tibiofibular synostosis combined with myoplasty and osseous medullary plugging and in three cases at a distal level at the transition between muscle and tendon of the triceps surae using myo

plasty knee disarticulation was carried out in four animals In two of these, disarticulation was combined with simultaneous partial resection of the femoral condyle, in a secondary stage the condyle was removed and the medullary cavity was exposed In eleven animals amputation of the femur was performed with myoplasty three of these had been subjected to amputation of the crus prior to amputation of the femur In four cases, amputation of the femur was combined with osseous plugging of the medullary cavity

To investigate the influence of incisions into skin and muscle on the MBF the crus and femur of five rabbits were incised and MBF subsequently measured In a further five animals the immediate changes in MBF after fracture of the crus were investigated

Surgery was performed in sterile conditions while the animals were under Nembutal anaesthesia After amputation through the bone the muscles were joined over the stump cortex from the removed bone was used for the medullary plugging In the cases of knee disarticulation the patellar ligament was sutured to the cruciate ligaments over the femoral condyle In the fracture cases the intermediate part of the crus was exposed a partial osteotomy was performed and the bone was fractured Healing was uncomplicated in 20 cases and a defect developed on the tip of the stump in one rabbit. After amputation of the crus the animals usually put weight on the stump while after knee disarticulation of the femur the stump was immobilized with a flexion contracture in the hip

After the operations the MBF in quadriceps and triceps surae on both sides was determined by means of 133 Xenon and Histamine thus agreeing with previous procedures (Hansen Leth 1976) The calculated MBF was expressed in per cent of the normal blood flow in the muscles concerned previously determined in 20 rabbits prior to operation MBF was measured postoperatively on 121 occasions within periods of time from 1 hour up to 130 days after operation with a total of 375 single measurements

RESULTS

In agreement with findings in a previous study (Hansen-Leth 1976), the course of the clearance curves was in general monophasic, and the fall set in immediately after the depot had been established In about one third of all the measurements, however, an initial stationary phase was seen, and measurements of the flow in the amputation stump also revealed that the rectilinear fall after 5 to 8 minutes was followed by a terminal rise in clearance

It seems that MBF in the amputation stump generally was decreased one hour after operation (Figure 1) After amputation of the crus, the mean flow was 76 per cent of the preoperative flow and after amputation of the femur, it was 55 per cent

Incision into skin, whether on the crus or femur, was also found to reduce the MBF in triceps surae (mean flow 65 per cent), and after incision into muscle the mean flow was 89 per cent Immediately after fracture of the crus the mean flow was 108 per cent of the preoperative flow

After *amputation proximally on the crus,* combined with medullary plugging, the flow in the stump was increased up to 270 per cent on an average, while *amputation distally on the crus,* with myoplasty, was followed by an increase up to a mean flow of 179 per cent in the second week after operation After this period the flow was normalized

After *disarticulation in the knee* an increase in MBF in the left quadriceps was seen from day 3 after the operation, and the flow was increased throughout the period of investigation (Figure 1) Partial resection of the femoral condyle did not change this reaction, MBF was increased as seen after disarticulation, and from 4 to 130 days postoperatively the mean flow was 140 per cent After total removal of the femoral condyles, including opening of the medullary cavity, the flow was immediately reduced, but from day 3 it increased to a mean flow of 140 per cent and normalized again within a couple of weeks

Figure 1 illustrates that *amputation of the femur* was followed by an initial reduction and a later normalization in MBF in the stump, and in contrast to findings after amputation on a more dis-

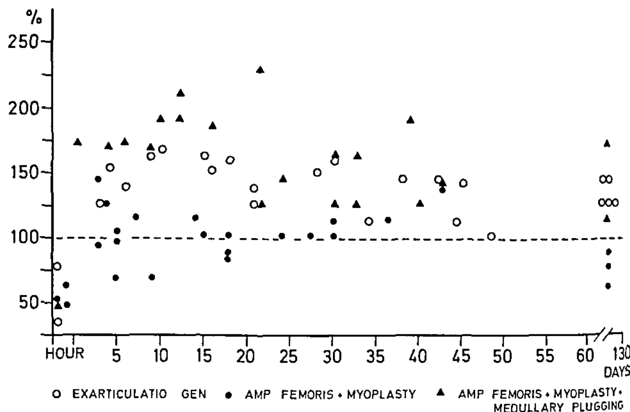


Figure 1 MBF in the amputation stump after knee disarticulation and after amputation of the femur with myoplasty and myoplasty combined with osseous medullary plugging from 1 hour to 130 days after operation

tal level, the flow in the amputation stump was not increased Similar changes were observed if amputation of the femur was preceded by amputation of the crus In the three rabbits in question, the mean flow in the crus stump was 290 per cent, while in the femoral stump it was 110 per cent of the pre operative flow

If *amputation of the femur* were combined with *osseous medullary plugging*, the initial reduction in MBF in the stump rapidly turns into an increased perfusion (mean flow 164 per cent) which remains intensified up to 10 weeks after the operation (Figure 1)

After amputation of the crus and after incision on skin and muscle, the mean flow in the contralateral quadriceps was slightly increased After knee disarticulation, the rise in flow in the ipsilateral quadriceps was followed by a uniform increase in MBF in the contralateral quadriceps (mean flow 131 per cent), but after amputation of the femur, the mean flow in the contralateral quadriceps was not intensified (97 per cent) When amputation of the femur was combined with osseous medullary plugging the increased MBF in the amputation stump was followed by an intensified flow in the contralateral quadriceps (mean flow 118 per cent) It appears, in general, that change in MBF in the ipsilateral quadriceps is followed by a uniform change in the flow in the contralateral quadriceps

DISCUSSION

In agreement with a previous investigation (Hansen Leth 1976), it was demonstrated in this study that MBF in the amputation stump was reduced immediately after operation, which may be explained by an involuntarily provoked

spasm (Eriksen & Olerud 1966) The reduction in MBF in the crus stump was followed by a uniform decrease in flow in the contralateral triceps surae A similar reaction was seen after incisions into skin and muscle while the MBF was not reduced after a fracture of the crus It has been observed by several investigators that trauma to an extremity was followed immediatey by an increased perfusion and a decreased flow in the contralateral extremity Sandegård (1974) observed that repeated blows to the femur of dogs brought about an increase in MBF, conversely, there was no similar change in flow after a closed fracture of the femur On the other hand, Wray (1964) observed in dogs that a closed fracture of the tibia was followed by an increased flow in the injured extremity and a reduced flow in the contralateral extremity Periosteal stripping and drilling through bone was not found to result in a changed flow, whereas trauma on only muscle would result in an increased MBF

Contrary to these findings, amputation brought about a decrease in MBF in the amputation stump, a reaction which must be of importance for the primary healing of the stump The initial reduction was more marked after amputation of the femur than after amputation of the crus, and the following rise in flow, seen after amputation of the crus, was not seen after amputation of the femur After knee disarticulation, a moderate though persistent rise in MBF occurred in the ipsilateral and the contralateral quadriceps Resection of the femoral condyle had no influence on the flow

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did not occur, and a calibre decrease was found in the larger vessels. These phenomena were not influenced by resection of the femoral condyle It was also observed by arteriography on live rabbits with amputations at different levels (Hansen-Leth & Karle 197-) that arteries would remain intact up to the level of amputation after amputation of the crus, while amputation of the femur would result in constriction of the femoral artery from the level of the hip joint In a clinical trial performed by Erikson (1965), arteriography disclosed that the diameters of arteries supplying the amputation stump were more markedly reduced after amputation of the femur than after amputation of the crus

According to these findings, the level at which amputation was performed was mainly responsible for the maintenance of the MBF in the amputation stump Another factor of importance was the closure of the medullary cavity It was observed in a previous study (Hansen-Leth 1976) that MBF increased to a greater extent after osseous medullary plugging than after closure by myoplasty In agreement with this observation, MBF increased when amputation of the femur was associated with plugging of the medullary cavity It has previously been shown that plugging of the medullary cavity might stimulate growth of bone (Trueta 1953), and Kellerová et al (1970) demonstrated in a clinical trial that intensification of the vascularization of bone after fracture was followed by a rise in MBF Hulth & Olerud (1962) are of the opinion that bone healing of the amputation stump is analogous with healing of a fracture The findings obtained in this study are in agreement with this supposition

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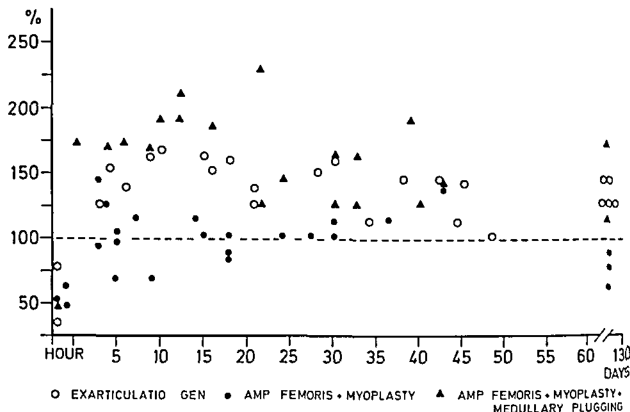


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It has been demonstrated in a previous study (Hansen Leth & Reimann 1973) that the level at which amputation is performed may play a role in the vascular reaction to amputation By arteriography, it has been demonstrated that after knee disarticulation contrary to crus amputation hypervascularization did not occur, and a calibre decrease was found in the larger vessels These phenomena were not influenced by resection of the femoral condyle It was also observed by arteriography on live rabbits with amputations at different levels (Hansen-Leth & Karle 197–) that arteries would remain intact up to the level of amputation after amputation of the crus, while amputation of the femur would result in constriction of the femoral artery from the level of the hip joint In a clinical trial performed by Erikson (1965), arteriography disclosed that the diameters of arteries supplying the amputation stump were more markedly reduced after amputation of the femur than after amputation of the crus

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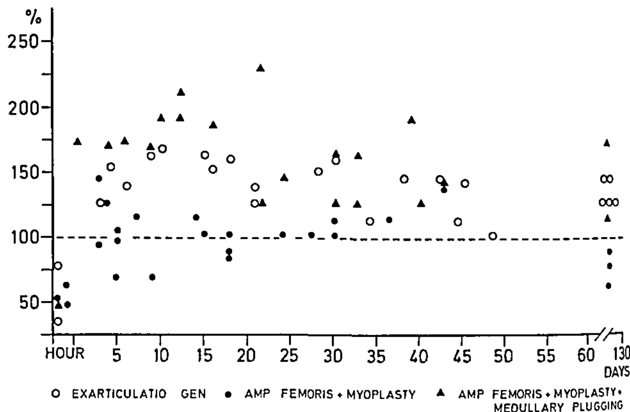


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According to the findings in this study, the postoperative increase in MBF in the amputation stump depends on the amputation level It is most pronounced after proximal amputation of the crus and is not seen after amputation of the femur In agreement with a previous investigation (Hansen-Leth 1976), it has also been shown that osseous medullary plugging intensifies the flow in the amputation stump

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OSTEOGENESIS AFTER BONE AND BONE-MARROW TRANSPLANTATION

I Studies with Combined Myelo-osseous Grafts in the Guinea Pig

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There has been conflicting evidence in the past regarding the contribution made to new bone formation by various components of a bone graft This study in guinea pigs has compared cortical and cancellous bone allografts both non decalcified and hydrochloric acid decalcified inserted into a muscular site for up to thirteen days both alone and combined with autologous bone marrow New bone formation was seen *only* if the implant contained fresh autologous marrow and it was not seen before the ninth day of implantation There were no differences in the cell populations about cortical and cancellous grafts Undecalcified bone evoked giant cell formation as well as new bone

Key words bone bone transplantation bone marrow cells, bone cells

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The stimulation of osteogenesis by combined myelo-osseous grafts has been used clinically (Boyne 1973) and experimentally (Pike & Boyne 1974) in several species

Results from bone allografts alone have been conflicting (Nade & Burwell 1976) and the contribution of the type of bone (cortical or cancellous) or its nature (calcified or decalcified) to osteogenesis after transplantation with marrow needs further investigation

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Studies on osteogenesis in the guinea pig using bladder mucosa (Huggins 1931) and other transplants (Bang 1973) have been reported, but the combined myelo osseous graft (Burwell 1964) has not previously been used in that animal

The morphological changes after bone and bone marrow grafting in guinea pigs are described in this paper During the first two weeks after transplantation, new bone formation is dependent on autologous marrow Whether the implant is calcified or decalcified does not influence osteogenesis, but giant cells are again seen around calcified implants (Nade 1970, 1973, 1976) These results are similar to earlier findings in the rabbit and rat

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Table 2

Implant — Duration (days)	Number implanted	Number retrieved	Number with new bone	Number implanted	Number retrieved	Number with new bone	Number implanted	Number retrieved	Number with new bone
	Control All allogeneic grafts alone (Not combined with marrow)			Non decalcified cortical implants combined with autologous marrow			HCl decalcified cortical implants combined with autologous marrow		
1	12	10		3	3	–	3	3	–
3	12	10		3	2		3	3	–
5	12	8		3	1	–	3	1	–
7	12	7		3	3		3	2	–
9	12	7		3	2	2	3	3	3
11	12	8		3	1	1	3	3	1
13	12	10		3	3	3	3	2	1
	Control Bone marrow autografts alone			Non decalcified cancellous implants combined with autologous marrow			HCl decalcified cancellous implants combined with autologous marrow		
1	6	4	–	3	2	–	3	2	–
3	6	3		3	3	–	3	2	–
5	6	4	–	3	1		3	1	–
7	6	3		3	2	–	3	1	–
9	6	2	2	3	3	2	3	3	1
11	6	3	2	3	1	1	3	2	1
13	6	3	2	3	3	2	3	3	2

Table 1 Types of implant used

Source of marrow-free allogeneic bone	Treatment before freezing for storage	Whether with marrow
Iliac cancellous	Non decalcified	Alone
	Non decalcified	Combined
	HCl decalcified	Alone
	HCl decalcified	Combined
Femoral diaphyseal cortical	Non decalcified	Alone
	Non decalcified	Combined
	HCl decalcified	Alone
	HCl decalcified	Combined
Nil	Nil	Autologous marrow Alone (2 grafts)
	Total	*10 implants*

MATERIALS AND METHODS

The experimental design was similar to that used by Salama et al (1973) and Nade & Burwell (1976), except that (i) the species studied was the guinea pig, (ii) the time period studied was up to two weeks, and (iii) autologous marrow was obtained from the femoral medullary cavity by needle aspiration through the opened knee joint

(a) *Donor bone*

Cortical bone was obtained from the diaphyseal femora and cancellous bone from the ilia of killed guinea pigs The bone for implantation was cut into pieces about 5 millimetres square Both types of bone were decalcified in 0 6 N hydrochloric acid at 2° C with continuous agitation, the cortical bone for 4 hours, and the cancellous for 1 5 hours

(b) *Insertion of implants*

The recipients were male guinea pigs bred by the University of Sydney Under anaesthesia the fibres of the external oblique muscle of the anterior abdominal wall were exposed a pouch opened between these fibres and the graft inserted The pouch was closed with a silk stitch Ten implants were inserted into each animal—one of each of the allografts alone, and two pieces of bone-marrow autografts served as controls for the combined myelo osseous grafts Table 1 shows the types of implants used

Retrieval of implants was made at 1 3, 5, 7 9, 11 and 13 days after insertion by killing the animal Three animals were used for each time period

RESULTS

Table 2 shows the number of implants for each time period, the nature of the implants, the retrieval rate for similar implants at each time period, and new bone formation rates

The histology is discussed in three groups

(a) Bone implants alone,
(b) Bone implants combined with autologous marrow,
(c) Marrow alone

(a) *Bone alone*

There was no major difference in the response seen after cancellous or cortical allogeneic bone implants

Day 1 The osteocyte lacunae were empty Extravasated red cells and fibrin were seen about the implants

Day 3 Some early cellular invasion of the implant was seen, more conspicuous on the trabeculae of cancellous implants A mild inflammatory response was noted in some sections

Table 2

Implant	Number implanted	Number retrieved	Number with new bone	Number implanted	Number retrieved	Number with new bone	Number implanted	Number retrieved	Number with new bone
Duration (days)	Control All allogeneic grafts alone (Not combined with marrow)			Non decalcified cortical implants combined with autologous marrow			HCl decalcified cortical implants combined with autologous marrow		
1	12	10	–	3	3	–	3	3	–
3	12	10		3	2		3	3	–
5	12	8		3	1	–	3	1	–
7	12	7	–	3	3	–	3	2	–
9	12	7		3	2	2	3	3	3
11	12	8	–	3	1	1	3	3	1
13	12	10	–	3	3	3	3	2	1
	Control Bone marrow autografts alone			Non decalcified cancellous implants combined with autologous marrow			HCl decalcified cancellous implants combined with autologous marrow		
1	6	4	–	3	2	–	3	2	–
3	6	3	–	3	3	–	3	2	–
5	6	4	–	3	1	–	3	1	–
7	6	3	–	3	2	–	3	1	–
9	6	2	2	3	3	2	3	3	1
11	6	3	2	3	1	1	3	2	1
13	6	3	2	3	3	2	3	3	2



Figure 1 The osteocyte lacunae of the implanted undecalcified allogeneic cancellous graft (ob) are empty In the centre of the field are several multinucleated giant cells (gc) arranged about bone spicule Fibrous tissue cells and stroma fill the intertrabecular interstices (Implant duration 9 days, haematoxylin and eosin × 100)

Day 5 Most implants showed evidence of connective tissue cell invasion The degree of fibroblast infiltration appeared greater with cancellous implants

At the periphery, the fibroblasts were arranged circumferentially Giant cells were seen around cortical and cancellous decalcified implants Apparent now in smaller numbers than in combined grafts were large ovoid mononuclear cells showing a round or oval, pale-staining nucleus with variable but usually faint basophilia, some had a nucleolus, a large nuclear/cytoplasmic ratio, and scanty, poorly eosinophilic cytoplasm whose boundary was often indefinable These cells appeared more plentiful in the graft interstices, but could be seen mingled with the fibroblasts Occasional polymorphs were noted

Day 7 The pattern established at day 5 persisted, but showed increased fibroblast and collagen formation with encapsulation of the implant, and increased numbers of giant cells around non decalcified implants (Figure 1)

Days 9, 11, 13 No significant change occurred The final picture was that of a fibrous tissue encapsulated implant The ovoid cells seen at day 5 became progressively less in number

In summary, for all bone allografts implanted alone

- No new bone was seen,
- Giant cells formed only around non decalcified implants,
- No cartilage cells were seen

(b) *Combined allogeneic bone and autologous marrow*

There were no differences noted between cortical and cancellous bone

Days 1 and 3 Early fibrous invasion was evident in the interstices of cancellous bone The number of red cells was variable and probably related to the trauma of implantation Fibrin was



usually noted Signs of a mild inflam matory response could again be detected at the junction of implant and traumat ised muscle Marrow cells were some times seen *but as above* the presence of fat spaces was the prime *guide to the* transplanted marrow

Day 5 Fibrous tissue *infiltration* in creased encapsulating *the transplant* *Fat* spaces were seen in some implants (Figure 2) Giant cells were *present* only in association with non *decalcified grafts*

Compared with bone alone there was an abundance of the large ovoid cells described above They were seen through out the cancellous interstices *especially but also in the* fibrous capsule mingled with the fibroblasts

Day 7 Apart from the impression *of* circumferential orientation of fibroblasts and collagen and the *abundance* of ovoid cells no difference *compared with the* fifth day was noted Implanted marrow was not identifiable

Day 9 New bone was seen in two thirds of the implants It formed in one or two foci exhibiting a trabecular pat tern in the majority Usually one part of the new bone abutted the implant on the cancellous trabeculae with cancellous im plants and on the concave surface of the cortical implant (Figure 3) In parts palissading osteoblasts were seen The new bone was always easily identifiable when present It was more basophilic showed a cement line and its lacunae were *small* and filled by viable osteo-cytes

The ovoid cells were very prominent *particularly* in association with the new bone Giant cells were only seen around non decalcified implants and never re lated to the newly *forming bone*

Days 11 and 13 Progressive fibrous and cellular infiltration of implant inter stices and fibrous *encapsulation* was seen The new bone was clearly recog



Figure 3 Newly formed bone (nb) abuts the implanted HCl decalcified allogeneic cortical graft (ob) which was combined with autologous marrow at the time of implantation The new bone stains more deeply, contains osteocytes and is lined by osteoblasts Ovoid cells (o) are seen amid the osteoblasts, fibroblasts and collagenous fibres (Implant duration 9 days, haematoxylin and eosin × 100)

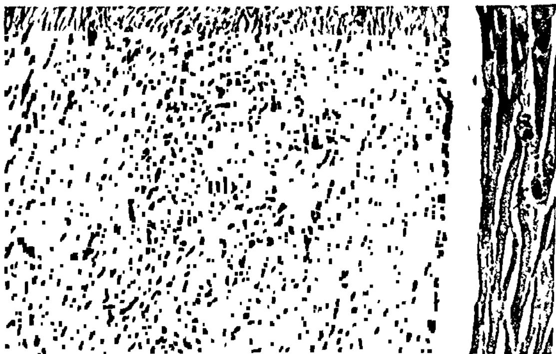


Figure 4 Newly formed bone (nb) and osteoblasts are seen at the site of an autologous bone-marrow graft 9 days after implantation It is surrounded by fibrous connective tissue and bone-mar row cells are not identifiable The muscle bed is adjacent (Haematoxylin and eosin, × 100)

nised Near the trabeculae of new bone ovoid cells were plentiful

Among the newly formed trabeculae numerous blood vessels were seen Giant cells were again only seen around non decalcified implants they were never associated with the new bone

Where the new bone did not form the appearances were the same as described under bone implants alone

(c) *Bone marrow autografts alone*

At those sites where bone formed the sequence of cellular events followed the same pattern as that described under combined grafts except

- (i) No bone implant was present
- (ii) No giant cells were seen
- (iii) The number of implants forming new bone was less than in the combined grafts (see Table 2)
- (iv) The formation of a fibrous capsule was less evident (Figure 1)

In the implants not forming new bone when the implant site was apparently located a mixed fibrous and cellular nodule was seen

DISCUSSION

The history of bone graft surgery is long and the publications on this subject are voluminous Although many attempts have been made to produce a material that would serve a useful function in a bone bank none has stood the test of time Indeed advances in surgical and anaesthetic techniques and modern metallurgy have given us the means to provide rigidity in places where bone is deficient and the majority of surgeons appear to favour the use of fresh autografts of cancellous bone for osteogenic function since their introduction by Math (1931) Mowlem (1941) and Abbott et al (1942)

Such grafts are in fact myelo-osseous combinations and the current series of investigations is an attempt to isolate the functionally osteogenic part of the graft In this way further approaches to a "bone bank may be possible—perhaps with the emphasis changed from the skeletal derivation of the material which inevitably dies to the stimuli which provoke active osteogenesis by living cells

The osteogenic potential of bone marrow

The fomation of bone in sites of autotransplantation of bone marrow is well established (Danis 1956 1959 1960 1973 Chalmers 1959 Burwell & Gowland 1961 Tavassoli & Crosby 1968 Nade 1970 Maniatis et al 1971 Patt & Maloney 1972) Although the tissue into which the marrow is transplanted has an influence on the formation of bone after such transplants Danis (1956 1960) was able to find newly formed bone on all sites that he studied The results reported in this paper show that marrow autografts to a muscular bed produced bone in 6 out of 42 *grafts (14 per cent)* If the graft duration was greater than 7 days bone was found in 6 out of 18 grafts (33 per cent) Yields of this order have also been recorded by Burwell (1964) in rats and Nade (1973) has shown a higher yield in rabbits The reasons for variability in the yields of new bone after marrow autografting include

- (a) difficulty in identification of the site of marrow implantation despite serial sectioning only 8 out of 18 implants were retrieved of which 6 (75 per cent) formed new bone similar to the studies of Danis
- (b) the possibility that cells may have disseminated from the implant site either by active migration or as a result of muscle contraction It may be that a minimal packing density of cells is required before bone forms (Friedenstein et al 1966 Amsel &

Dell 1971 a) Bone implants may assist by holding sufficient marrow cells in the implanted site to allow bone formation (Burwell 1964),

(c) There may be a phase between marrow implantation and repopulation as such during which the response to surgical trauma is no longer apparent (Maniatis et al 1971),

(d) The possible effect of inductors or repressors of osteogenesis in the micro-environment of the transplanted marrow (Urist 1965, Nade & Burwell 1976) This study confirms that autografts of living bone marrow are osteogenic when placed into a muscular bed Combination of autologous marrow with chemically treated, dead allografts of bone significantly increased the number of sites in which bone formed

Does the type of allogeneic bone or its treatment influence osteogenesis?

Because of their inability to reproduce the results of Urist's group, Nade & Burwell (1976) suggested that there may be *differences in the influence that cortical* and cancellous allogeneic bone have on bone-marrow osteogenesis Decalcified bone as a stimulus for osteogenesis was first suggested and used by Senn (1889) and subsequent studies have shown that decalcification with hydrochloric acid may be the most effective way of producing an implant which stimulates osteogenesis (Burwell 1966, Urist et al 1968)

In this series of experiments in the guinea pig, there has been *no* (qualitative) difference shown between cortical and cancellous bone as the allogeneic component of the myelo-osseous grafts, *and also* there was no difference, in terms of new bone formation, between implants which had been decalcified with 0 6N HCl or left undecalcified

The time of the first appearance of new bone

New bone was not seen in animals killed on the seventh day after implantation, but on the *ninth* day it had appeared Therefore, for such an appearance of woven bone, recognisable as a tissue, the critical programming event in cell specialisation, be it differentiation of a previously uncommitted cell type, or transformation by induction, or redifferentiation, must occur in the first few days after marrow transplantation This time sequence is not different from that found in the rabbit (Nade 1976), but contrasts with the findings of Urist et al (1972) who stated that the guinea pig was a slower bone former than other species However, his *group has experi*mented with bone allografts alone and claimed that an inductive process due to a component resident within decalcified bone evoked bone formation in a muscle bed 24 28 days after implantation in the rabbit New bone formed after marrow autotransplantation forms much earlier and the cellular interactions involved may be quite different

The cells seen about the implants

(a) Multinucleated giant cells were seen only about non-decalcified implants—either cortical or cancellous They were apparent as early as the fifth day and were located only about the implant and never in relation to newly formed bone The early ap*pearance of these cells in a non* sensitised animal makes a specific immune rejection mechanism unlikely Why these cells are seen remains an enigma, but could relate to the chemical or physical composition of the allograft

(b) The cells described as ovoid cells appearing from the fifth day onwards may be the same as those called primitive mesenchymal cells,

reticular cells or pre osteoblasts by previous workers (see Amsel & Dell 1971 b) They appeared more plentiful in combined myelo osseous grafts and in those implants forming bone were abutting the newly formed bone Radioisotope studies or electron microscopy (Thorogood & Gray 1975) could help in their identification and warrants further study

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SUMMARY

1 Histological study was made of the fate of bone allografts impregnated with autologous marrow and grafted to a muscular site in guinea pigs for 1 to 13 days
2 Four principal types of marrow free allogeneic bone were evaluated

(a) Iliac cancellous bone non decalcified
(b) Iliac cancellous bone decalcified with HCl
(c) Femoral cortical bone non decalcified
(d) Femoral cortical bone decalcified with HCl

Each of the four types was frozen for storage and later implanted with and without autologous marrow which was obtained from the recipient s femoral medullary cavity
3 New bone formation was only seen if the implant contained autologous *marrow* The new bone was not seen before 9 days of implantation
4 Autografts of marrow *alone* formed bone in 6 out of 8 sites after 9 days
5 There was no difference in the cell populations that formed about cortical or cancellous allografts
6 Undecalcified bone cortical or cancellous evoked giant cell formation as well as new bone

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SUPERIOR MESENTERIC ARTERY SYNDROME COMPLICATING TREATMENT WITH BALANCED TRACTION

A Case Report

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A brief review of the superior mesenteric artery syndrome is given A case is reported which occurred after 9 weeks of treatment of a fractured femur by continuous traction with balanced suspension The condition was successfully treated by conservative measures including a plaster hip spica allowing frequent changes of position The importance of early diagnosis and prompt treatment is emphasized

Key words mesenteric artery syndrome, fracture of the femur, balanced traction, duodenal obstruction, complication to treatment

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Compression of the duodenum by the superior mesenteric artery is most often called the superior mesenteric artery syndrome Other names, e g , arteriomesenteric ileus and Wilkies disease, are used as well In orthopaedic practice the syndrome is most well-known as "the cast syndrome" as it may follow body cast application for example, in the treatment of scoliosis (Dorph 1950, Bunch & Delaney 1970, Soreff 1973 Warner et al 1974, Bisla & Louis 1975 and others)

The syndrome can also appear during prolonged bed rest in the supine position, as in the treatment of fractures by continuous traction with balanced suspension A case of this type is reported

CASE REPORT

An 18 year old man of asthenic habitus with no earlier gastro intestinal symptoms sustained a fracture of the shaft of the left femur and a fracture of the right radius but no abdominal lesions The fracture of the femur was treated by continuous traction with balanced suspension (Figure 1) After 9 weeks of immobilization in the supine position the patient developed symptoms and signs of a high ileus Radiographic examination (Figure 2) revealed a compression occlusion of the distal part of the duodenum The condition was recognized as the superior mesenteric artery syndrome and it was decided to treat the patient conservatively with gastric suction and parenteral nutrition The dehydration alkalosis and hypokalaemia were corrected The balanced suspension was removed, and a plaster hip spica was applied to permit frequent changes of the position of the patient This treatment was successful and the symptoms and signs of ileus disappeared in a couple of days The symptoms returned to a lesser degree 4 weeks later when the patient still had not been mobilized with his plaster hip spica and the changing of position was not so frequent [illegible]
applying [illegible]
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his plaster hip spica with a pair of crutches and treatment was continued on an outpatient basis Since that time there have not been any gastro

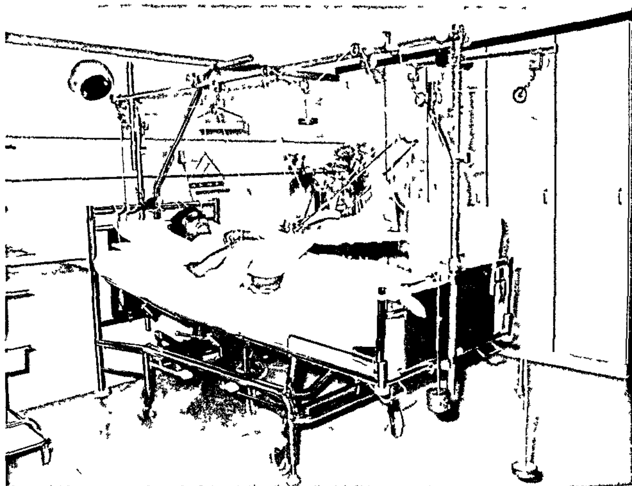


Figure 1 Sustained traction with balanced suspension as used in the case described The patient shown is not the one reported

intestinal problems The exact change of his weight from before the accident until the beginning of his ileus is not known but there was a considerable weight loss

DISCUSSION

The superior mesenteric artery syndrome is a vascular compression obstruction of the duodenum, the transverse portion of which is the most fixed part of the alimentary tract, placed retroperitoneally between the aorta and the vertebrae posteriorly and the root of the mesentery of the small bowel anteriorly Here it is placed like a nut between the jaws of a nutcracker, with a movable anterior and an immobile posterior jaw When the distance between the "jaws" becomes too narrow duodenal compression occurs

The anatomic basis of this vascular compression of the duodenum is further described by Akin et al (1974)

Several causes have been given, and some of these are

1 Marked rapid loss of weight including loss of the retroperitoneal fat, so that the superior mesenteric artery impinges more directly on the duodenum
2 Prolonged bed rest in the supine position
3 Asthenic habitus
4 Increased lumbar lordosis and decrease in the scoliosis angle
5 Weak abdominal musculature
6 Prolonged abdominal compression, e g, by plaster body cast

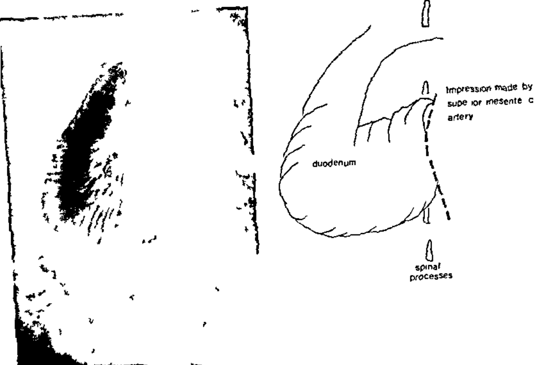


Figure 2 The rad ograph c f nd ngs lead ng to the liagnosis A c mpression at the l stal part of the luodenum (AP projection the pat ent in the supine posit on)

Several of the factors are often involved in the development of the syndrome

Three categories of the superior mesenteric artery syndrome can be distinguished Firstly there is a group of patients who after for example a scoliosis operation and immobilization in a body cast or plaster hip spica rapidly (in a few days) develop the type of the superior mesenteric artery syndrome described as the cast syndrome The second group includes patients with severe war injuries (Wayne et al 1971) and patients with severe burn injuries (Rechler et al 1972) Characteristic for the patients described by Wayne and Rechler is prolonged bed rest in the supine position with loss of weight followed by the superior mesenteric artery syndrome after 10 to 37 days Patients with a more chronic and intermittent version of the syndrome constitute the third group (Jones et al 1960)

The clinical picture of the acute syndrome is that of high intestinal obstruction with gastric dilatation and vomiting of bile stained material In the less acute form there is postprandial epigastric fullness with epigastric pain or vague and ill defined epigastric discomfort after eating This may be associated with anorexia malaise nervousness easy fatigability marked mental depression and emotional instability If not treated the pernicious vomiting may lead to hypovolaemia alkalosis hypokalaemia and to shock and death

The diagnosis should be confirmed by radiologic examination Under fluoroscopy with the patient in different positions the occlusion can be seen to diminish to a greater or lesser extent in some positions a fact which can be used therapeutically These observations under fluoroscopy also prove that the superior mesenteric artery syndrome is a reality

This has been questioned by Cimmino (1961) and others

As soon as the diagnosis is established, prompt treatment including gastric suction, parenteral nutrition and correction of hypovolaemia and hypokalaemia should be started If possible the position of the patient should be changed frequently If the symptoms persist for more than 24 hours, casts and plasters should be removed If this treatment is impossible or unsuccessful, surgical intervention is indicated

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EPIDERMAL BONE CYST OF THE FINGER

A Case Report

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An epidermal cyst of the terminal phalanges of the fingers is a rare finding The present work deals with some of the clinical and pathological aspects of such a case seen by the authors

Key words bone neoplasms, epidermal bone cyst

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Epidermal cysts of bone are quite rare Most of them occur in the skull, but they may occasionally be observed in the distal phalanges (Bissel & Brunschwig 1937, Kleinsasser & Albrecht 1957, Roth 1964 Dahlin 1967, Lichtenstein 1970)

Because of the rarity of phalangeal epidermal cysts, the presentation of such a case may be of interest

CASE REPORT

A 33 year old man had for many years noticed a thickening of the distal phalanx of his left little finger but it had not caused any discomfort

He visited his doctor because of acute pain in the finger following a slight trauma The primary treatment was for a fracture without dislocation

A couple of weeks later he was admitted to [illegible] X ray [illegible] of the [illegible] tumour [illegible] well demarcated although with some cortical usuration A fracture line was seen crossing the cyst (Figure 1) Clinically the diagnosis was that of an enchondroma Primary amputation of the terminal phalanx was performed because of the extension and localisation of the lesion

Pathological examination

The specimen consisted of the distal phalanx of the left little finger It was cut longitudinally at the midline Most of the bony phalanx was occupied by a cystic tumour with greasy, greyish coloured masses in the lumen (Figure 2)

Histological sections through the entire phalanx were prepared and stained with haematoxylin eosin Azan Heidenhain and Weigert's Elastin van Giesson

Apart from a small area, the cyst wall was seen microscopically to be lined by a regular stratified squamous epithelium The epithelium varied in thickness, in many places with multiple layered stratum spinosum and granulosum The cyst lumen was filled with stratified horny masses and fatty material (Figure 3) Where the covering epithelium was missing a mainly histiocytic reaction with several giant cells of the foreign type was seen In this area the corticalis seemed to be destroyed too, but the soft tissue outside the bone was only minimally affected

DISCUSSION

According to the literature most of the patients with epidermal cysts of the phalanges are young male adults, as in the present case A traumatic origin of the cysts following a mild to severe

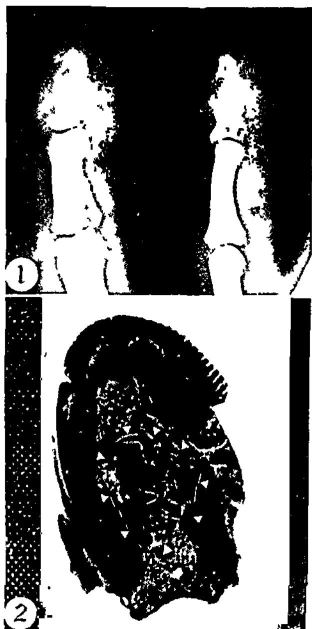


Figure 1 Roentgenograms (anteroposterior and oblique views) showing a lytic defect with a thin sclerotic border A fracture line is seen traversing the cyst

Figure 2 Longitudinal section through the terminal phalanx of the little finger The border of the cyst is marked

crushing type of injury is suggested by most authors Injuries to the nailbed seem in this connection to be of importance (Behrens 1931, Fisher et al 1958, Roth 1964)

As in the present lesion, epidermal cysts may easily be confused clinically with enchondroma, more rarely with osteomyelitis The clinical symptoms which in our case seemed classic are not different from those of enchondroma Radiographically epidermal cysts appear as rounded lytic areas with clearly defined borders without the mottled appearance often seen in enchondroma The distinction may however be difficult to make (Bissel & Brunschwig 1937, Fisher et al 1958, Lichtenstein 1972)

A definitive diagnosis is established by histological examination and is dependent upon the demonstration of a squamous epithelial lining in at least some portion of the cyst wall In cases with curetted material and prominent granulomatous reaction the impression of a benign giant cell tumour may be obtained, especially if the material is sparce (Fisher et al 1958)

The treatment of choice is curettage



Figure 3 Histological specimen showing the epidermal cyst within the bone Horny stratified material is seen in the lumen (H E × 175)

possibly with filling of the bony defect Recurrence seems to be rare Because of a marked bony defect an amputation may have to be performed as in the present case (Roth 1964)

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ULTRASTRUCTURE OF PROLAPSED DISC

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Prolapsed tissue and removed interspace contents were obtained during hemilaminectomy for disc prolapse The ultrastructure of the tissue was studied Division of the material into *annulus fibrosus* and *nucleus pulposus* proved to be inaccurate Chondrocytes were always the predominant cell type and could be classified into normal cloning and necrotized types Matrix vesicles were found in relation to the haloes of chondrocytes and seemed to be products of disintegrated chondrocytes Findings of crystals in the vesicles were rare The intercellular substance showed degraded collagen fibrils, which could be seen in spindle shaped cells as well A dense amorphous material interpersed with collagen fibrils seemed to be a glycoprotein A few elastic fibres were found, but without any evidence of severe degeneration These findings represent changes occurring in cells and in the intercellular substance

Key words intervertebral disc displacement, ultrastructure, chondrocytes, matrix vesicles collagen, proteoglycan, glycoprotein elastic fibres

Accepted 22 xi 76

Knowledge of the ultrastructure of undisplaced human discs is based on examinations of necropsies from normal spines (Sylvén et al 1951, Watanabe 1960, Dahmen 1963, Gomibuchi 1964, Render 1971, Inoue 1973, Takeda 1975, Inoue & Takeda 1975) and biopsy material from scoliotic spines obtained during surgical operation for wedge resection (Cornah et al 1970, Meachim & Cornah 1970, Meachim 1972)

Hence, the interpretation of the ultrastructural findings on a prolapsed disc is hampered by incomplete knowledge of the structure of the fresh normal disc, and, furthermore, by specific difficulties due to the mixed nature of prolapsed specimens (Brown 1971)

These may be the reasons why no comprehensive study on the ultrastructure of the displaced intervertebral disc has been carried out since 1963–64 when Dahmen, Happey et al and Gomibuchi reported their findings Because of the less developed preparation technique they used, a more detailed ultrastructural picture of prolapsed discs is still unavailable

MATERIAL AND METHODS

Specimens were obtained during hemilaminectomy for disc prolapse from six patients (three males and three females) ranging from 31 to 70 years of age The patients had had significant clinical symptoms for 2 to 9 months The level

[1] Supported by a fellowship from the Danish Rheumatism Association



Figure 1 A chondrocyte surrounded by a halo consisting of a pericellular lacuna (P) and fine collagen fibrils (F) Outside the halo a collection of matrix vesicles (MV) × 6 000
Inset Proteoglycan granules are seen in the pericellular lacuna Ruthenium red stain × 60 000

f herniation was L_4 or L_5 According to surgical findings five patients had a protruded disc One disc was found to be ruptured

According to their anatomical position the tissue specimens were classified into a herniated part and an intervertebral part

The tissue specimens were fixed in a 6 per cent glutaraldehyde solution in 0 1 M cacodylate buffer at pH 7 4 with 7 5 sucrose at 4° C and smicated with 1 per cent osmic acid After dehydration of the specimens in graded alcohols they were embedded in Epon 812 and ultrathin sections were stained with uranyl acetate and lead citrate Some sections were also stained with ruthenium red (Kobayasi & Asboe Hansen 1971) and periodic acid silver proteinate (Thiéry 1967

A Siemens electron microscope was operated at 80 kV with double condensors

OBSERVATIONS

The chondrocytes were surrounded by a halo consisting of a pericellular lacuna and an outer fibrillar ring Three different types of arrangements could be identified In one type, a single oval cell was found to be surrounded by a thick fibrillar ring made up of collagen fibrils with a diameter of 100–200 A (Figure 1) Inside this the pericellular lacuna contained numerous granules with delicate branches The granules stained with ruthenium red representing high contents of proteoglycans (Figure 1 inset) The chondrocyte showed a large nucleus with one nucleolus The cytoplasm contained Golgi cisternae, distinct granular endoplasmic reticulum a few mitochondria lysosomes and fat droplets

A second type of arrangement consisted of one or several cells encircled by one common halo (Figure 2) The halo was formed of an outer narrow fibrillar part and an inner broad proteoglycan part The cells had short cytoplasmic processes which did not reach the fibrillar ring The cells contained a well developed granular endoplasmic re-

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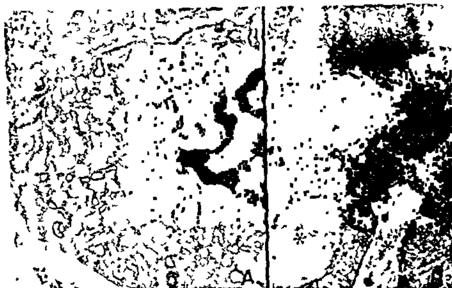


Figure 4 A A spindle shaped cell containing collagen fibrils × 15 000

Figure 4 B Detail of engulfed collagen fibrils (asterisks) × 60 000

ticulum, mitochondria lysosomes, and dilated vesicles The Golgi apparatus was dilated with proteoglycan figures in the cisternae (Figure 2 inset a) Fat droplets and numerous PAS positive glycogen particles were deposited in the cytoplasm of some of the cells (Figure 2 inset b)

The third type of arrangement consisted of one or occasionally two cells surrounded by an often poorly defined fibrillar ring The cells were necrotic and had a dark cytoplasm with lucent spaces containing proteoglycan figures (Figure 3) The cytoplasmic details could not be identified except for the large fat droplets In the immediate vicinity of the cell surface large numbers of membrane invested vesicles were found (Figure 3 inset b)

A common finding in all the observed haloes was the presence of membrane-bounded vesicles located immediately outside the fibrous ring They often appeared at one side of the periphery, lending the group a semilunar shape in section In the first two of the above-described chondrocyte arrangements, the vesicles were never found inside the halo The individual vesicle was round oval or kidney shaped (Figure 3 inset a) The size varied from 500 to 3 000 A with a modal value of approximately 1 000 A It was bounded by a double membrane and contained a material of varying density However, empty vesicles were also found Sometimes the limiting membrane was disrupted, and extrusion of vesicle contents could be seen Rarely, fine crystalline formations could be identified inside the vesicles, but only provided no counterstaining had been used

A minority of cells had no chondrocytic appearance These cells were spindle shaped without a halo and were always found in the dense fibrillar tissues (Figure 4) They held a distinct granular endoplasmic reticulum, lysosomes and often phagocytized collagen fibrils

The intercellular substance consisted of collagen fibrils proteoglycans, dense amorphous material, filament bundles with cross bands and occasionally, elastic fibres

In the prolapsed part of the discs, the



Figure 2. Chondrocytes surrounded by one common halo. Broad pericellular lacuna (P). Thin fibrillar ring (F). Matrix vesicles (MV). × 6,000.

Inset a. Detail of dilated Golgi cisternae containing proteoglycan figures × 60,000

Inset b. Glycogen particles (GP) in the cytoplasm of a chondrocyte. Periodic acid silver proteinate × 30,000.

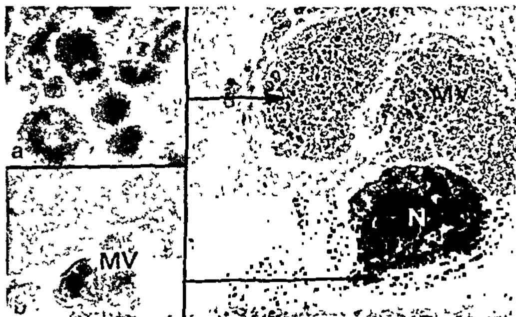


Figure 3. Necrotic chondrocyte (N). Lots of matrix vesicles (MV) are seen in the pericellular lacuna × 6,000

Inset a. Pleomorphic matrix vesicles lying in cluster formation × 60,000

Inset b. Matrix vesicles at the surface of necrotic chondrocyte. The plasma membrane is disrupted × 60,000



Figure 4A A spindle shaped cell containing collagen fibrils × 15 000

Figure 4B Detail of engulfed collagen fibrils (asterisks) × 60 000

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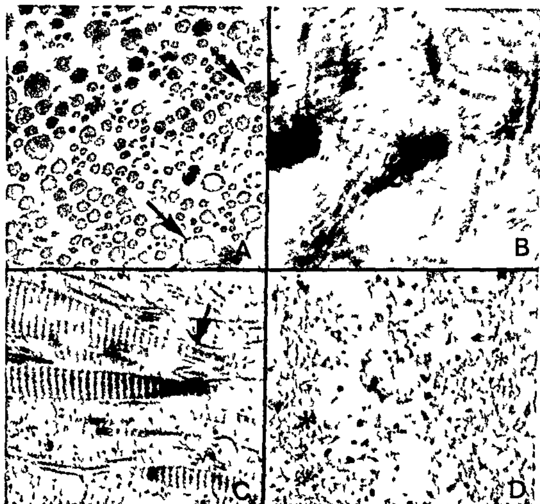


Figure 5 A Abnormal collagen fibrils showing varying diameters and irregular margins (arrows) × 30 000

Figure 5 B Disarranged collagen fibrils showing curled and bent shapes × 60 000

Figure 5 C Thick collagen fibrils showing tapered ends (arrow) × 30 000

Figure 5 D Cross banded filamentous bundles (asterisks) × 60 000

most densely packed collagen was noted while in the intervertebral part more proteoglycan figures and less collagen fibrils were present An absolute correlation between fibrillarity and the presumed contribution of annulus fibrosus to the tissue as estimated by the *in situ* location of the specimen was however not found

The collagen fibrils when tightly packed were running parallel to each other in firm bundles In the case of looser arrangement no predominant direction of the fibrils was found The axial periodicity was always normal The range of the diameters was 100 4 000 A However most fibrils had diameters within the range of 300 2 500 A but they varied considerably between the fibrils even within small areas (Figure 5 A) Pathological phenomena such as irregular cut surfaces curling bending and tapered ends were common (Figure 5 A B C)

The dense amorphous material was seen in large compact masses or spread out interspersed between the collagen fibrils or bundles (Figure 6 A) Numerous proteoglycan figures were seen in this material The material was periodic acid silver proteinate positive (Figure

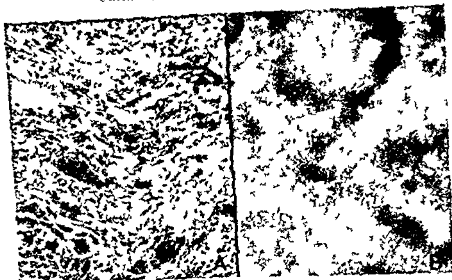


Figure 6 A Dense amorphous material interspersed with collagen fibrils × 6 000

Figure 6 B The dense amorphous material surrounding collagen fibrils showing staining with periodic acid silver proteinate × 60 000

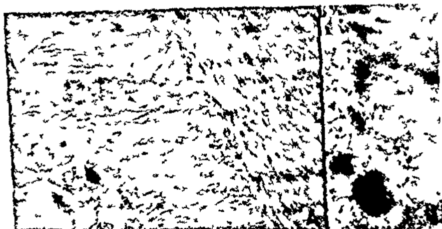


Figure 7 A Tightly packed collagen fibrils on the right hand side of the micrograph while left the micrograph shows a loose arrangement of the collagen fibrils with proteoglycan figures and elastic fibres (arrow) × 6 000

Figure 7 B The arrow pointed elastic fibre in Figure 7 A A matrix vesicle is seen × 60 000

6 B while the ruthenium red staining turned out to be more *faint*

Filamentous bundles with cross bands with a periodicity of 800 000 Å (Figure 5 D) were usually located at the haloes of the chondrocytes However they were never found in the first described chondrocyte type

Elastic fibres were identified especially at the borderline between the *annulus fibrosus* and the *nucleus pulposus* (Figure 7) They appeared without fibrils but were coated with a PAS-positive *material*

DISCUSSION

In the present study, the prolapsed tissue and removed contents of the disc interspace have been described

The first chondrocyte arrangement described represents the healthy cells found in discs of scoliotic spines (Meachim & Cornah 1970, Meachim 1972) and the chondrocytes in the middle layer of normal articular cartilage (Weiss 1973, Lane & Weiss 1975) The cells are believed to take part in the normal turnover of the matrix

The second type of chondrocyte arrangement shows cloning cells and evidence of increased secretion It is found in degenerating cartilage (Weiss 1973) and is interpreted as an attempt at repair, compensating for loss of intercellular substance

The third chondrocyte type characterizes a stage of cell death Necrotic chondrocytes are a frequent observation in discs of scoliotic spines and are found in osteoarthritic cartilage as well (Weiss 1973) Surrounding the necrotic cell remnant, we found numerous membrane-bounded bodies which seem to be identical to the matrix vesicles first described by Anderson (1967) and Bonucci (1967) They are believed to play a major role in calcification of the tissue in which they are found Their origin is still a matter of debate (Rabinovitch & Anderson 1976)

As necrotic cells in our material were the only cells having matrix vesicles in their pericellular lacuna, it seems likely that they are produced only by these cells

The rare ocurrence of crystals inside or in the vicinity of matrix vesicles disagrees with the finding that the major function of matrix vesicles should include calcification of the prolapsed disc Whether the matrix vesicles in the prolapsed disc play a role in the degeneration of the matrix or merely reflect necrosis of chondrocytes seems unclear

Our finding of varying diameters of collagen fibrils has formerly been described in prolapsed tissue, but in undisplaced necropsy tissue as well (Sylvén et al 1951, Dahmen 1963, Render 1971) and, therefore, it can hardly be recognized as a pathological phenomenon However, a greater range of diameters was found in our material The cross sections of fibres most frequently showed irregular margins This has been described in collagen after exposure to collagenases (Keech 1954, Kobayasi et al 1977) and is supposed to represent an effect of a collagenolytic agent

The tapered ends of fibrils are believed to represent the same phenomenon This type of collagen change has been described in the prolapsed disc by Dahmen (1963)

The pathological curling of fibrils has also been observed in skin disease, such as necrobiosis lipoidica (Kobayasi et al 1974) and shagreen patch (Kobayasi et al 1973) No causative mechanism of the change is known

Cross-banded filamentous bundles appear in the intervertebral disc of humans (Cornah et al 1970) and in rabbits (Smith & Serafini-Fracassini 1968) They are described most frequently to be located in the pericellular matrix, and we believe they are a type of collagen They have been found in other connective tissues as well, and in organ cultured skin, they have turned out to be degradative products of collagen due to collagenolytic activity (Hentzer & Kobayasi 1975) The same mechanism may be responsible for their formation in the disc

The dense amorphous material is supposed to be a glycoprotein, as it stains heavily with periodic acid silver proteinate Hence, the substance might be identical to a glycoprotein identified in increased concentrations in older discs (Pearson et al 1972) In our observa

tions the affinity of the collagen for this material agrees with its preferred location between collagen fibrils

Elastic fibrils in discs have been described recently by Buckwalter et al (1976) In our specimens elastic fibres were primarily located at what we believe to be the borderline between the annulus and the nucleus A concentration at this location is reasonable and fits with the theory that a necessary condition for their formation is a tensile force combined with a cross force (Little 1973)

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UNILATERAL AND BILATERAL PARTIAL LAMINECTOMY IN LUMBAR DISC PROLAPSE

A Follow up Study of 156 Patients

ROLF HAGEN & LARS B ENGESÆTER

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The results of two comparable groups of in all 156 operated patients with lumbar disc prolapse were evaluated 4–9 years postoperatively Sixty seven patients had received bilateral and 89 unilateral partial laminectomy At follow up the results of the bilaterally operated were all excellent or good whereas 15 per cent with unilateral exposure were unchanged or worse The unilaterally operated presented a significantly higher incidence of low back pain and recurrences of sciatica than the bilaterally operated There were no reoperations for recurrent prolapses following the bilateral approach compared with four after unilateral approach It is concluded that bilateral partial laminectomy affords a good view of the disc pathology and a greater possibility for obtaining relief of the symptoms without reducing the stability of the column

Key words lumbar disc prolapse sciatica intervertebral disc displacement surgical approach unilateral and bilateral partial laminectomy

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The best surgical approach in lumbar disc prolapse is still a matter for discussion The communications in the literature vary considerably regarding the operative technique and the results of the operative treatment (Armstrong 1951, Connolly & Newman 1971, Hakelius 1970, O Connell 1951, Raaf 1970, Rosen 1969, Simeone 1971) No method seems to be generally accepted

One reason for this great divergence in results may be the preoperative heterogeneity of the various materials In addition the psychosocial and economic aspects of these lesions play an important and steadily increasing role and have a perceptible influence on the pre- and postoperative evaluation Lastly, the diagnostic ability of the surgeon and his surgical skill must be taken into consideration

Little has so far been reported about different operative methods in prolapse surgery from one department The purpose of this study is to evaluate the late results of two different exposures, unilateral and bilateral partial laminectomy, especially concerning the relief of sciatica, postoperative low back pain, recurrence of severe sciatica and surgery for recurrent prolapse

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flexed to spread the lumbar interlaminar spaces

The choice of exposure was quite independent of the preoperative symptoms and signs It only depended upon which method the surgeons mostly four, experienced either as operators or assistants were accustomed to use

The surgical indications in our hospital are very restrictive As a general rule surgical intervention is not considered justified without prior conservative therapy for at least 6 weeks In addition our department emphasizes the importance of pre and postoperative treatment with exercises and therefore it is of interest to mention that the mean period of hospitalization was 45 days in both groups

As can be seen in Figure 1 the sex and age distribution and the mean age at operation were rather similar in the two series

The statistical analysis between the groups has been performed with the χ^2 test with Yates' correction

Follow-up examination

All the 156 patients were examined 4–9 years after the operation partly by personal examination and partly by a questionnaire the average observation time being 5 7 years in Group I and 6 6 years in Group II Three patients had died from heart disease but sufficient information regarding their previous back disorder was given by the relatives and the postoperative examinations documented in the records

RESULTS

As indicated in Table 1, there are only minor differences between the groups as regards the preoperative status *defined* according to various parameters in the clinical history A similar uniformity regarding the preoperative signs and myelographic findings is documented in *Table 2* [illegible] 9 cases graphic [illegible] the reason being hypersensitivity *to the* contrast medium or clinically convincing symptoms By review of the X rays of the lumbosacral column no preponderance of *general* lumbar disc degeneration was displayed in either of the series

It can be seen from Table 3 that seven cases (8 per cent) in Group II were operated at the L_4/S_1, and the L_5/S_1 levels Four had protrusions and two negative findings The last one was only explored at one level and the discs were judged to be quite normal at the primary operation

Table 1 Preoperative status in 156 patients with unilateral and bilateral partial laminectomy

	Group I Per cent	Group II Per cent
Type of work		
heavy manual	26	24
manual	40	38
non manual	34	38
Previous low back pain	84	91
Onset of sciatica		
acute	56	47
gradual	44	53
Localisation of sciatica		
right	50	49
left	50	51
Pain on coughing and sneezing	85	69
Duration of symptoms		
0–3 months	47	49
4–6 months	53	51

Table 2 Signs and myelographic findings in 156 patients with unilateral and bilateral partial laminectomy

	Group I Per cent	Group II Per cent
Positive Lasegue's sign	97	84
Impaired sensibility	53	66
Impaired Achilles reflex	43	49
Pareses	47	55
Myelography		
positive	96	91
negative	1	1
not performed	3	8

The percentage of free, sequestrated prolapses is strikingly high, more so in Group I than in Group II, but the difference is not significant ($P > 0.10$) The designation "extruded prolapse" includes not only a free sequestrum in the spinal canal but also an extruding prolapse through a rupture of the annulus *or the* posterior longitudinal ligament

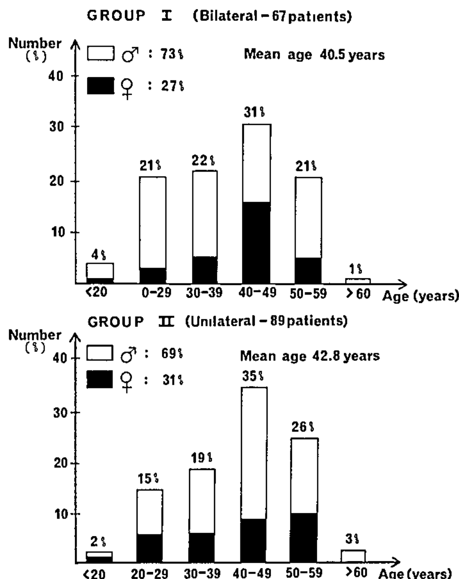


Figure 1 Sex and age distribution of 156 patients with unilateral and bilateral partial laminectomy

MATERIAL AND METHODS

During the period 1967–1971, 249 patients were operated for lumbar disc prolapse at Martina Hansens Hospital In order to get two comparable groups preoperatively with the exposure as the only variable parameter, 156 patients fulfilled the following criteria

1) Maximum of 6 months duration of symptoms after the attack of sciatica which led to the operation
2) Unilateral symptoms of sciatica
3) Affection of the fifth lumbar and/or the first sacral nerve root
4) No previous operation for lumbar disc prolapse or other back disease

Treatment

In Group I 67 patients were treated by bilateral partial laminectomy The muscles were detached from the spinous processes and the laminae to the intervertebral joints About one third of the spinous process facing the intervertebral space was chiselled off and the ligaments removed The laminectomy was more extensive on the prolapse side, here occasionally including the medial border of the joint facet without destruction of the intervertebral joint The disc was incised and completely emptied on both sides

In Group II with 89 patients an interlaminar unilateral exposure was performed with detachment of the muscles and extirpation of the ligaments only on the prolapse side After minimal removal of the adjacent edges of the laminae, the disc was incised and emptied as completely as possible from one side only

All the patients were operated on in the prone position with rolls placed under the shoulders and the chest wall and the table usually

Group I were a 48-year-old woman with predominantly psychosocial problems, a 60-year old man with co existing painful hip arthrosis and a 61-year old man with 50 per cent disability Nevertheless, they stated the results of their operated back as being "good , which was also con firmed by objective examination

Table 5 Long term effects in 156 patients with unilateral and bilateral partial laminectomy

	Group I Per cent	Group II Per cent
Low back pain	30	51
Recurrence of severe sciatica	13	26
Returned to work within		
½ year postoperatively	91	80
Lighter work	12	9
Reduced physical activity	18	40
Disability insurance	4	12

Recurrences

Among the 156 patients six were re operated during the follow up time Two surgical explorations for suspected recur rent prolapses in Group I revealed one case with discitis and one with adher-ences on the previously prolapsed side

However three patients in Group II were reoperated for massive, free, seques trated prolapses at the same level and *on the same side* 1 2 years after the primary exposure A free sequestrum was also present at the initial operation in two of them The fourth patient with manifest clinical signs of prolapse was exposed unilaterally at one level in 1967, but the exploration of the last two lumbar spaces failed to provide any explanation for the condition The decompression of the laminectomy apparently *improved* the symptoms, but bilateral laminectomy through two levels in 1969 revealed an overlooked sequestrated prolapse with adherences of the 5th and a new extrusion of the 4th disc

DISCUSSION

The two groups can be compared reason-ably well because of their similarity in composition and in the various param-eters demonstrated Therefore, the pre-ponderance of successful results in Group I should indicate a more rational and effective surgical exposure

However, strong objections can be raised This is a retrospective study with-out randomized groups Moreover, the surgeons have used only their own ex-posure routinely Thirdly, a minor pre-ponderance of free extruded prolapses in Group I, even if it is not statistically significant, might point to a more ad-vanced process of degeneration, seques-tration and extrusion among these pa-tients A more "ripe" prolapse is known to give a more successful result (Burns & Young 1951)

On the other hand, it is very doubtful whether the increased incidence of low back pain in Group II can be explained by the higher mean age at operation (2 3 years) and the longer follow up period (0 9 year) These differences are con-sidered too small to influence the results

The arguments against the unilateral interlaminar approach are that it affords a poor view and prevents complete emp-tying of the disc The importance of com-plete removal has been pointed out by several authors (Armstrong 1951, Raaf 1970, *Rosen 1969) For these reasons* a partial bilateral laminectomy should be preferred

The objection to total laminectomy and to some extent hemilaminectomy is that it produces a reduced postoperative stability of the column, resulting in low back pain (Connolly & Newman 1971) However, Jackson (1971) and Naylor (1974) reported no difference in the in cidence of low back pain among patients with wide laminectomy and those with the interlaminar approach

The bilateral exposure as described in

The peroperative complication frequency in the material is 6 per cent dural ruptures in Group I against 11 per cent in Group II In addition, late complications included one patient with discitis in the former group and one with spondylitis in the latter group

Table 3 Disc levels and findings at operation in 156 patients with unilateral and bilateral partial laminectomy

	Group I Per cent	Group II Per cent
Operated disc level		
L 4/L 5	54	50
L 5/S 1	46	42
L 4/L 5 + L 5/S 1	0	8
Findings at operation		
Extruded prolapse	43	33
Protrusion	57	64
Negative	0	3

At follow-up, the state of the patients was classified according to the criteria presented in Table 4, mainly judged from their subjective assessment of functional ability The bilaterally operated were all "excellent" or "good" while 15 per cent with unilateral exposure were "unchanged" or "worse" This difference is statistically significant ($P < 0.005$) If only the "excellent" results are taken into consideration the difference is highly significant ($P < 0.001$) In Table 5 the significantly higher incidence of low back pain in Group II ($P < 0.05$) is noteworthy

In addition, there were nine patients (13 per cent) in Group I and 23 patients (26 per cent) in Group II with recurrences of severe sciatica (Table 5) Whereas 6 and 18 patients in Groups I and II, respectively, had recurrences in the same limb as the initial syndrome, it was interesting to note that only two in Group I as against three in Group II experienced the new attack of sciatica on the opposite side to their previous prolapse The last three patients reported that they had bilateral recurrences The designation of an episode of severe sciatica as recurrent sciatica during the follow-up period implies an official sick registration or hospitalization for at least 3 weeks

The three patients (4 per cent) receiving disability insurance and belonging to

Table 4 Results of follow up examination in 156 patients with unilateral and bilateral partial laminectomy

	Group I Per cent	Group II Per cent	
Excellent Symptom free or occasional minimal residual symptoms normal working ability	64	34	91 per cent satisfactory
Good Slight symptoms full time occupation in lighter work	36	51	
Unchanged Significant symptoms unable to work or doing light work periodically	0	2	9 per cent unsatisfactory
Poor Not relieved of major preoperative symptoms or worse postoperatively disability insurance owing to the back disease	0	13	

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The bilateral exposure as described in

the present study by no means implies such an extensive procedure as a total or hemilaminectomy The anatomy of the spinal column presents great individual variations, especially in the width and the position of the laminae In some patients the interlaminar space, particularly at the L_5/S_1 level, is sufficiently wide to permit removal of the protruding intervertebral disc with minimal bilateral excision of bone

The incidence of recurrent herniations at the same or another level reported in the literature varies between 0 per cent and 24 per cent with an average of 10 per cent (Stauffer et al 1971) In the present series the rate amounts to scarcely 2 per cent, and the only overlooked prolapse and the three recurrent prolapses at the same level were seen among the unilaterally exposed patients

Recurrence at the level of the original prolapse is probably due to continuation of the biochemical, degenerative process resulting in a loose sequestrated nucleus or annulus fragment Considerable degenerated tissue may be present, and after withdrawal of a free sequestrum or a bulging disc a radical removal of the interspace from both sides and across the midline with a conchotome is indicated Lastly, a curettage is performed leaving only the anterior and lateral rims of the annulus intact We have also found it valuable to record routinely the weight of the disc tissue removed at operation At the follow up examination this figure tells something of how radical the previous disc excision was

The follow-up gives the impression that the bilateral partial laminectomy is a more valuable and safe procedure than the unilateral one, which perhaps may be insufficient in a given case The better exposure affords a good view of the pathology and a greater possibility for ensuring relief of the symptoms Bilateral exploration does not seem to induce an increased postoperative morbidity or to influence the integrity or the stability of the spinal column to any great extent Our material indicates that postoperative adhesions with severe sciatica contralaterally to the previous prolapse rarely occur among bilaterally exposed patients

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POSTERIOR VERSUS LATERAL APPROACH FOR HIP ARTHROPLASTY

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In a study of two groups of 100 patients each with a similar composition (age sex and indications for surgery) operations for total hip arthroplasty took half as long and the blood loss was clearly less when using the posterior route in one group compared with Charnley s conventional approach in the other group These are important considerations for elderly patients with a high operative risk Radiologic assessments showed that with the posterior approach there was a wider variation in the location of the cup in the frontal plane However this has not caused any inconvenience during the short observation period to date No comparison has been made of the functional results over an extended period

Key words hip surgery total hip replacement surgical approach bleeding and hip surgery

Accepted 12 I 77

Major advances in hip surgery have been achieved during the last two decades chiefly through the work of Charnley (1972) His operative method with a lateral approach and trochanteric osteotomy is generally accepted but many surgeons have found that it takes a long time (Thompson & Culver 1975 Sculco & Kanawat 1975 Koide et al 1974)

The present retrospective study concerns 100 patients who underwent total hip arthroplasty via posterior incision and 100 having the same operation via a lateral incision as described by Charnley The two groups were compared with respect to the duration of the operation the amount of blood transfused the operative complications and the position of the acetabular cup in a frontal radiographic projection

PATIENTS AND METHODS

An analysis of the two groups of patients according to age and sex is given in Table 1 The indication for surgery was osteoarthrosis rheumatoid arthritis or persistent disability after fracture of the femoral neck or acetabulum (Table 2) Cases of infection after earlier prosthetic surgery were excluded but the groups do contain patients with no signs of infection after an earlier Judet or Moore prosthesis

The 100 patients in one group were operated on with one of the approaches at the Department of Orthopedics at Gavle Hospital during the period May 1973 to December 1974 and the other approach was used in 100 patients at the Department of Orthopedics at Falun Hospital during the period January to December 1974

The posterior approach was undertaken largely as described by Lubinus & Jacobsen (1973) The incision ran laterally over the proximal femoral shaft and then curved away in a dorsal direction Fascia lata and gluteus maximus were split along the fibres The short rotator muscles

were cut and were not re sutured The femur was cut through at the neck after dislocation which only occasionally required the prior removal of osteophytes from the acetabular rim The patient lay straight on one side and the cup was positioned in about 15–20° anteroversion at an angle of 40–45° in the frontal plane The operation was performed with the Brunswick instrumentarium

Table 1 Mean age and sex distribution in the two groups

	Posterior approach	Trans-trochanteric approach
Mean age	66 years	66 years
Men/women	48/52	46/54

Table 2 Indications for the operation

	Posterior approach	Trans trochanteric approach
Osteoarthrosis	80	81
Rheumatoid arthritis	9	9
Persistent disability after fracture	11	10

In the Charnley group the patient was supine A lateral incision was made and the trochanter was cut with a Gigli saw The acetabulum was ground out fairly extensively and the cup was positioned at an angle of about 45° in the frontal plane but with no antero or retroversion In keeping with Charnley's basic principles attempts were made to lateralize and distalize the trochanter when making re attachment the aim being to increase the leverage of the gluteal muscles The instruments advocated by Charnley were used

Antibiotics were administered prophylactically in both groups (Cloxacillin 4 g daily for 1 week starting on the morning of the operation)

The operations with the posterior approach were performed by one of four surgeons (of whom three were senior surgeons) while ten surgeons (five of them senior) were involved in the Charnley group

A neuroleptic anaesthesia (Pavulon Leptanal) was used in all cases with the posterior approach while epidural anaesthesia predominated in the lateral group

The total amount of blood transfused was compared in the two groups instead of studying the degree of per and postoperative bleeding The indications for transfusion appear to have been similar in the two hospitals (subjective and objective hypovolaemia haematocrit below 30) and therefore this amount should give a comparable picture of the total blood loss

Postoperative dislocation has been included in the comparison if it could be demonstrated radiologically but not if it was only subjective partial dislocation or a feeling of dislocation upon flexion medial or lateral rotation of the hip

The position of the acetabular cup has been measured only in the frontal plane This was done by a radiologist for a random sample of 30 patients in each group The angle between the cup and a line joining the two tubercles was calculated It would have been desirable to assess the position of the cup in a lateral projection too but no X rays of this projection were available for many of the patients in the Charnley group

Prophylactic treatment for thrombosis was given in conjunction with the posterior approach, only in the form of Lohman bindings on the leg postoperatively and oxyphenbutazon 0 1 g × 3 In the Charnley group every patient received Macrodex prophylactically for thrombosis (500 ml on the day of the operation followed by 500 ml on the 3rd and 5th days post operatively)

The patients have been followed for at least 1 year after the operation

RESULTS

The average duration of the operation and the amount of blood transfused are shown in Table 3 Even when the comparison is confined to operations performed by senior surgeons, the difference in average duration is still considerable (55 and 112 minutes, respectively)

Table 3 Average duration of operation and amount of blood transfused per and postoperatively

	Posterior approach	Trans trochanteric approach
Duration of operation	55 min	122 min
Blood transfused	650 ml	1600 ml

Blood loss as reflected by the amount transfused per- and postoperatively, is clearly smaller with the posterior approach In this group, moreover, no blood transfusion at all was required in 28 cases compared with only one case with the lateral approach

A comparison of major complications noted in the case records is given in Table 4

Table 4 Complications

	Posterior approach	Trans trochanteric approach
Death	1	0
Sciatic paresis	3	1
Dislocation	1	1
Deep infection (suspected)	1	1
Haematoma	1	0
Infarct	(1) fatal	1
Thrombosis	1	7
Pulmonary embolism	0	4
Slight trochanter problem	0	2

The operative technique caused no problems in either group In one case in the Brunswik material however, the shaft of the prosthesis perforated the femur re operation gave a satisfactory result

The position of the cup in the frontal plane resulted in an average angle of 43° for patients in the Brunswik group and 44 for those with the lateral approach As shown in Figure 1, however, the posterior approach gave a wider dispersion around the mean

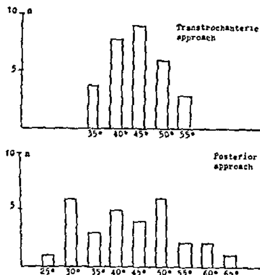


Figure 1 Distribution of the cup position in the frontal plane determined radiographically

DISCUSSION

The transtrochanteric approach used to be and in many places still is the conventional route for total hip arthroplasty However as this operation takes rather a long time and problems are encountered with the trochanter (Lubinus & Jacobsen 1973 Buchholz & Noach 1973 Thompson & Culver 1975), many authors prefer other surgical incisions, such as those described earlier by Kocher (1911) and Osborne (1930) With the posterior approach, an operation with the Brunswik prosthesis is reported by Lubinus & Jacobsen (1973) to take an average of 50 minutes, whereas with the transtrochanteric route it takes more than 2 hours (Thompson & Culver 1975, Sculco & Ranawat 1975, Koide et al 1974)

The two groups which are compared in the present study have practically identical distributions as far as sex, age and indications for the operation are concerned The clear, statistically significant differences which have been found between them in the duration of the operation and the blood loss must be regarded as of major importance, considering that this type of operation is performed as a rule in old patients with a high operative risk Apart from the approach and the surgeons involved the two groups differ in principle only in the type of anaesthesia Total arthroplasty with epidural anaesthesia gives a lower blood pressure during the operation and a smaller loss of blood (Jacobson & Wigren 1972, Sculco & Ranawat 1975), in addition to

the shorter duration (Sculco & Ranawat 1975) With the same type of anaesthesia, the difference between the groups would therefore presumably be still more marked Whether Macrodex given prophylactically for thrombosis should cause more bleeding in the Charnley group is difficult to say

In the present group with the lateral approach, the trochanter posed no problems, in contrast to other studies (Weaver 1975, Thompson & Culver 1975) Neither was postoperative dislocation any problem in either of the groups studied The single instance in the transtrochanteric group occurred 40 days after the operation, the joint was reduced and the patient has been free from symptoms ever since The only dislocation with a Brunswik prosthesis occurred in the second postoperative month, traction therapy was given for 4 weeks and the patient was free from symptoms at follow-up one and a half years after the operation In this case the position of the cup in the *frontal plane was acceptable but a lateral* projection showed 5–10° retroversion, which may have contributed to the dislocation

It is commonly considered that dislocation after hip arthroplasty occurs more frequently with the posterior approach However, in a survey of late results of 1350 Brunswik prostheses with this approach, Lubinus (1973) found only five dislocations, which is one of the lowest figures for a large material of total hip replacements This may be due *to the greater depth of the Brunswik cup* compared with Charnley's, as well as to its larger head on the shaft and its position with about 20° anteroversion With the transtrochanteric approach and Charnley's instruments, the frequency of dislocation in several other reports is relatively high three dislocations after 100 operations (Dall 1975), six after 126 (Thompson & Culver 1975) and, from Sweden, 13 after 283 (Bergstrom et al 1973), Charnley (1973) himself had six dislocations among 185 patients followed for 9–10 years

Many factors would seem to contribute to a dislocation Lubinus (1973) mentions the position of the cup, retro- or anteroversion of the prosthetic shaft and the length of its neck In the present *group with the posterior approach, the* position of the cup in the frontal projection showed a definitely wider variation radiographically It is possibly somewhat *more difficult to site the cup correctly* when the patient is in a lateral rather than a supine position In the same way as Lubinus (1973), we have found that with experience it is not difficult to ensure the correct position of the cup with the posterior approach

The death in the group with the posterior approach concerned a man of 73 with heart disease The operation took 45 minutes and the patient lost 300 ml of blood He died on the 4th postoperative day and autopsy revealed old as well a *fresh cardiac infarcts but no sign of pu* monary embolism

There were more cases of sciatic pare sis after the posterior approach but non of the four patients in the two group combined required bandaging on th account at the follow-up examinatio This paresis disappears as a rule withi 1 4 months (Lubinus & Jacobsen 1973 and its frequency with the posterior ap proach is reported to be about 1 per cen

One case of suspected deep infectio has been noted in each group Both pa tients had a *persistently high ESR 1 yea* after the operation but no radiographi or subjective symptoms of infection Th observation time is too short and th number of cases too small to warran further discussion of this parameter

In the case of venous thrombosis an pulmonary embolism, the diagnostic cri terion is of major importance and ma have differed between *the two groups* However, one cannot ignore the possibil

ity that the higher frequency of pulmonary embolism in the transtrochanteric group and perhaps even the seven cases of calf thrombosis had to do with the longer duration of the anaesthesia and the operation

The operative technique did not cause any problems in either group We were unable to confirm the opinion of Thompson & Culver (1975) that the posterior approach is less suitable for patients with malposition of the hip in lateral rotation

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THE USE OF BONE CEMENT AS AN ADJUNCT TO INTERNAL FIXATION OF SUPRACONDYLAR FRACTURES OF OSTEOPOROTIC FEMURS

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Bone cement was used as an adjunct to internal fixation of 14 supracondylar femoral fractures The fractures were stabilized with ASIF plates In all these fractures severe osteoporosis made a stable fixation impossible without the use of bone cement The average age of the patients was 75 years Eight of the patients had previously been operated on because of fractures of the same extremity and three suffered from disabling diseases Twelve fractures healed without complications, despite early mobilization One fracture needed additional external fixation before it healed and one lead to non union No infections were seen It is concluded that use of bone cement as an adjunct to the internal fixation of supracondylar fractures secures a stable fixation of even the most severe osteoporotic femora and this aids healing in most cases of such fractures The method is recommended in selected cases of elderly patients

Key words internal fixation, supracondylar femoral fracture, bone cement

Accepted 15 x 76

Until a few years ago conservative treatment was considered superior to internal fixation of supracondylar femoral fractures in adults (Stewart et al 1966, Neer et al 1967) However, the development of new fixation devices and techniques has, according to several investigations, improved the results of the treatment of these fractures Thus, the use of the ASIF-condylar plates, as suggested by Muller et al (1965) in most cases secures a stable fixation of an ideally reduced fracture and makes early mobilization possible, resulting in excellent or satisfactory results (Slatis et al 1971, Olerud 1972, Chiron et al 1974) Nevertheless, in supracondylar fractures of severe osteoporotic femora there are still problems in obtaining a stable fixation

The use of bone cement as an adjunct to internal fixation of fractures, as suggested by Muller (1962), may also be applied in the treatment of supracondylar fractures of the severely osteoporotic femur In our department, bone cement has been used as adjunct to internal fixation in such fractures since 1968 The purpose of this paper is to present the results of the method

PATIENTS AND METHODS

There were 14 female patients with fractures through the supracondylar region of the femur without affection of the knee joint Severe

Case	Age (Yrs)	Type of fracture	Previous disease or operatively treated fracture	Healing time in months	Follow up	Walking function		Axis
						Before injury	After healing	
1	86	Transverse comminuted	Hemiplegia	3½	10 months	Confined to bed	Confined to bed	Recurvation 10 degrees
2	74	Oblique comminuted	Coxarthrosis	Non union	16 months	1 stick	2 crutches	Normal
3	82	Oblique comminuted	Polyarthritis	3	6 years	Confined to bed	Confined to bed	Recurvation 5 degrees Varus 5 degrees
4	63	Transverse comminuted	None	4½	6 years	No aids	1 stick	Valgus 5 degrees
5	74	Short oblique	Tibial shaft fracture Tibial condylar fracture	4½	3 years	No aids	No aids	Normal
6	84	Transverse	Femoral neck fracture Supracondylar femoral fracture	4	7 months	No aids	No aids	Valgus 5 degrees
7	84	Long oblique	None	4	4 years	No aids	No aids	Varus 15 degrees
8	71	Long, oblique	Femoral neck fracture	3	8 months	2 crutches	2 crutches	Normal
9	58	Short, oblique	None	4	5 years	No aids	No aids	Normal
10	92	Oblique, comminuted	Femoral neck fracture	3	4 months	Confined to bed	Confined to bed	Normal
11	71	Long, oblique	Femoral neck fracture (nailed, femoral head prosthesis, total hip prosthesis) Femoral shaft fracture	4	14 months	2 crutches	2 crutches	Normal
12	76	Transverse	Tibial condylar fracture	3	18 months	No aids	1 stick	Normal
13	71	Transverse	Femoral neck fracture (nailed, Cup-a pl) Supracondylar femoral fracture	4	10 months	2 crutches	2 crutches	Normal
14	75	Long	Femoral neck fracture (nailed femoral head prosthesis, total hip prosthesis)	4	5 months	2 crutches	2 crutches	Recurvation 5 degrees

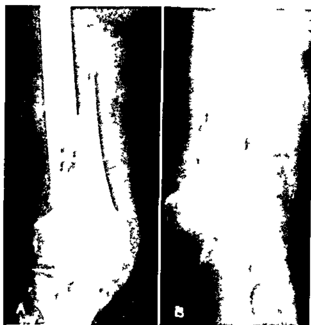


Figure 1 A and B Radiographs of a supracondylar femoral fracture (Case no 8 Table 1) The pictures demonstrate a severe osteoporosis in the supracondylar region



Figure 1 E and F Radiographs 3 months after operation The lateral view reveals that the fracture has been bridged by bone posteriorly There is no abundant periosteal callus formation No signs of loosening of the screws are seen The axes are unchanged from the first postoperative examination (compare with Figure 1 C and D)

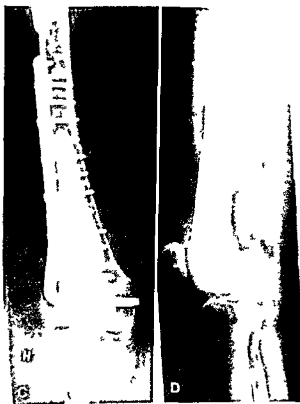


Figure 1 C and D Postoperative radiographs The intramedullary cavity is filled with bone cement The condylar plate has been fixed with screws through the implanted cement

osteoporosis was found during operation in al these patients The degree of osteoporosis wa so severe that fixation by plates and screws wa insufficient without adjunctive use of bon cement Eight of the patients had previousl been operated on for fractures of the sam extremity three suffered from disabling diseas of the locomotor system while three suffere from osteoporosis only Their ages varied fron 58 to 92 years with an average of 75 years Th relevant data are given in detail in Table 1 The total number of patients admitted fo supracondylar femoral fractures in the cor responding age group was 57 only seven o these were treated conservatively

Operation method

The fractures were all operated on according to the ASIF principles using condylar plates (Muller et al 1965) except in one case where a straight plate was used The fractures were reduced and a channel for the blade of the plate was prepared with a special chisel Bone cement

(Simplex P) of a doughy consistency was packed into the medullary cavity and the blade of the plate was inserted before the cement had cured. If there was not a considerable defect at the fracture site due to comminution of the fracture the fracture had to be redislocated in order to install the cement. Subsequently the fracture was finally reduced. Attempts were made to place the cement strictly intramedullarily. After the cement had cured, holes were drilled through the bone and the cement, the holes were tapped and the cortical screws were fastened giving a firm attachment of the plate to the femur. One example of an operated fracture is shown in Figure 1.

The operations were performed without sterile enclosure. Prophylactic antibiotics were not used.

Postoperative treatment

The patients were generally kept in bed for a couple of days, the knee of the operated leg being immobilized in a semiflexed or ninety degrees flexed position by use of a splint. Walking exercises were then started, the patients using a walkerette and later crutches. Only partial weight bearing was allowed until the fracture was found to be consolidated.

RESULTS

The results were examined by clinical and radiological investigations at varying intervals. The length of the follow-up periods varied from 3 months to 6 years. Details are given in Table 1.

One patient died of pneumonia after reoperation for non union (case no. 2). The fractures of all the other patients healed from 3 to 5 months after operation. All these fractures healed without change of the axis established at the operation, except one which had to have a plaster cast for two months following redislocation of the fracture two months postoperatively (Case no 7). Some of the other fractures healed with slight angulation; this was due to inaccurate reposition and not to failure of the fixation. There were no refractures. Periosteal bone formation was rather scanty in most of the fractures (Figure 1).

No exact information can be given about the influence of the fracture on the mobility of the knee joint, most of the patients had a reduced mobility of the knee even before they sustained their supracondylar fracture. The walking function after healing of the fracture was in most patients slightly or moderately impaired.

DISCUSSION

The material presented represents the most unfavourable cases of supracondylar femoral fractures in a group of elderly patients. All the patients suffered from severe osteoporosis and impaired walking function due to previously sustained fractures of the same extremity or to disabling diseases. The findings at the operations revealed that stable fixation was impossible without the use of bone cement. Hence, the results cannot be compared with results obtained in unselected materials.

The fact that 12 of the 14 fractures healed without changes of alignment after 3 to 5 months despite early mobilization shows that supracondylar fractures even in the presence of severe osteoporosis are likely to heal when bone cement is used as an adjunct to adequately placed ASIF plates. It is worth noting that the failures of fixation, one leading to non-union and one necessitating additional external fixation, were due to technical errors in the application of the plates and not to loosening of the screws from the bone cement itself.

According to Cameron et al. (1975), the strength of the cement screw complex is significantly higher when the screws are pushed into soft cement than when the screws are fixed after drilling and tapping in cured cement. However, the latter method which was employed in the present study proved reliable for securing a firm fixation in the severely osteoporotic femur.

The application of bone cement did



Figure 1 A and B Radiographs of a supracondylar femoral fracture (Case no 8 Table 1) The pictures demonstrate a severe osteoporosis in the supracondylar region



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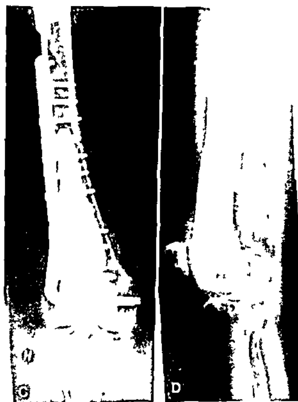


Figure 1 C and D Postoperative radiographs The intramedullary cavity is filled with bone cement The condylar plate has been fixed with screws through the implanted cement

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Operation method

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OSTEOSYNTHESIS OF MEDIAL FRACTURES OF THE FEMORAL NECK BY SLIDING NAIL-PLATE FIXATION

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Sliding nail plate osteosynthesis of displaced medial fractures of the femoral neck was carried out in 65 consecutive cases The appliance presented here differs from other sliding nail plates as it has no fixed angle between the nail and the plate Immediate postoperative weight bearing was permitted The average follow up period was 2 2 years Union of the fractures was seen in 74 per cent and avascular necrosis in 21 per cent Complications were few which we attribute to the early mobilization of the patients

Key words early weight bearing medial fractures of the femoral neck sliding nail plate osteosynthesis

Accepted 22 xi 76

In patients with displaced medial fractures of the femoral neck an osteosynthesis sufficiently solid to permit immediate weight bearing is desirable but of course without increasing non union or avascular necrosis

It is generally agreed that in medial fractures of the femoral neck full reduction of the fracture and rigid apposition of the fracture surfaces are of particular importance but there is no agreement as to which sort of internal fixation satisfies these aims best

Sliding nail plate osteosynthesis was earlier reported by Pugh (1955) Massie (1958) and Brown & Abrami (1964) The purpose of this study is to present the findings of a consecutive series of 65 displaced medial fractures of the femoral neck treated with sliding nail plate osteosynthesis and with immediate postoperative weight bearing

MATERIAL AND METHODS

This study includes all patients with displaced medial fractures of the femoral neck treated in the Orthopaedic Department Ø Odense University Hospital between March 1972 and March 1974 There were 65 patients 51 women and 14 men The average age was 74 1 years ranging from 48 years to 93 years The age distribution is given in Table 1

The fractures have been divided according to Garden s (1961) classification Stage 1 incomplete fracture (impacted valgus fracture) Stage 2 complete fracture without displacement Stage 3 complete fracture with partial displacement Stage 4 complete fracture with full displacement

Only fractures in stage 3 and stage 4 have been considered in this series Pathological fractures have been excluded

Operation was performed at the first opportunity but not as an emergency After admission to hospital 16 patients were operated within 24 hours 10 patients between 24 hours and 48 hours and 13 patients between 48 hours and 72 hours On admission to hospital traction (usually without internal rotation) was applied through the tibial tubercle Final adjustment of

not seem to prevent the process of healing This might be due to the efforts of confining the bone cement to the medullary cavity Similar findings have been made when bone cement has been used in the upper end of the femur in the stabilization of intertrochanteric fractures (Harrington 1975) On the other hand, no abundant periosteal bone formation could be seen as an effect of the use of bone cement This is in contrast to what was seen when bone cement was used in intertrochanteric fractures (Harrington 1975)

In some cases it was difficult to assess radiologically the exact extent of the fracture healing, since some parts of the fracture space were hidden by the applied cement However, the fact that there were no cases of refracture indicates that firm osseous healing really occurred It seems unreasonable that the fractures should remain stabilized only because of the internal fixation itself However, it should be noted that not all the operated limbs were exposed to maximal weight-bearing Most of the patients used some walking aids, partly because they were more or less disabled before they sustained their supracondylar femoral fracture

Even though there were no cases of postoperative wound infections in the present series, the risk of this complication must not be neglected since infection after use of bone cement might be disastrous to the end result On the other hand, if stable internal fixation is not obtained, this may lead to delayed union or non-union *Unstable internal fixation* of supracondylar femoral fractures also implies a greater risk of infection (Stewart et al 1966, Neer et al 1967) Occasionally, inadequate fixation may even lead to a combination of complications necessitating amputation of the limb (Haukebø 1976)

When severe osteoporosis is present traction treatment might be an alternative method to internal fixation with adjunctive use of bone cement However traction treatment includes the risks of general complications of long-lasting immobilization of elderly patients and necessitates a prolonged stay in a surgical unit

Taking account of these considerations and the results of the operations it seems advisable to recommend the adjunctive use of bone cement for internal fixation of supracondylar fractures of the severely osteoporotic femur in elderly patients

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a anterior posterior position *b lateral position*

Figure 9 Radiographs of the sliding nail plate in a femoral neck fracture

3 Doubtful union At the follow up there were two patients (3 per cent) with no clear evidence of bone union but there were no signs of failure either

Avascular necrosis was seen in seven patients (21 per cent) who had all previously shown bone union Union was found in stage 3 fractures in 94 per cent and in stage 4 fractures in 61 per cent (Table 2)

In 38 cases with good reduction of the fracture 76 per cent united (Table 3) In 26 cases with good position of the sliding nail 82 per cent united (Table 4)

Postoperative complications were found in 21 patients as listed in Table 5 In one case we had to remove the appliance one year after the operation because of a deep infection There were no signs of phlebothrombosis or pulmonary embolism Prophylactic anti coagulation was not used in the series

In 10 cases the osteosynthesis failed Two cases showed poor reduction of the fracture as well as a poor position of the sliding nail Within the first three months another two patients had a new trauma with redisplacement of the fracture In a further two cases the sliding nail telescoped out of the femoral head and in three patients no obvious explanation was found

In the last of the failures the femoral head tilted when the nail was inserted

Table 1 Age distribution of 65 patients with medial fracture of the femoral neck and number of deaths before the follow-up

Age	40–49	50–59	60–69	70–79	80–89	90–	*Total*
Number of patients	1	4	15	16	21	8	65
Number of deaths before follow up	–	–	1	2	7	2	12

the reduction was made under general anaesthesia on the fracture table with fluoroscopy and image intensifier

The appliance which is illustrated in Figure 1 consists of a partial trifin nail sliding in a circular barrel The telescopic property of the *nail allows progressive impaction as resorption* occurs at the fracture site, without any risk of the nail penetrating the articular surface of the femoral head The compressed nail is inserted over a guide pin, and with a special driver the trifin nail is driven into position to 0 5 cm below the articular surface of the femoral head The nail should be placed at as steep an angle as possible resting on the femoral calcar and a *little posterior and inferior to the centre* of the femoral head Lastly, the nail is connected to a three hole plate by a topbolt (Figure 2 a and b)

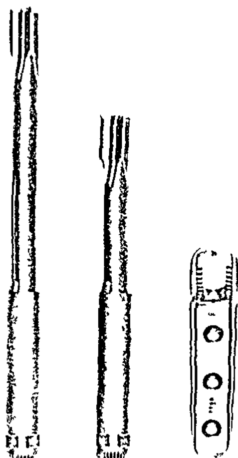


Figure 1 The sliding nail plate material The nail component is shown in its longest and shortest position

In the postoperative treatment we aimed at an early mobilization If there were no contraindications the patient would sit in a chair the day after the operation, and on the second or third day, the patient was permitted to walk with elbow crutches Weight bearing on the operated leg up to the threshold of pain was allowed The patients have been followed with clinical and radiographic examination until either union of the fracture or failure was manifest

At the follow up 12 (18 per cent) patients had died Six patients refused to come to hospital for radiographic examination and one patient was an American tourist They have all been excluded from the results In the remaining 46 patients clinical and radiographic examinations were made at the follow-up The average follow-up period was 2 2 years ranging from 1 2 years to 3 5 years

RESULTS

The results were divided into three groups

1 Union was seen in 34 patients (74 per cent), *and this implies bone union of* the fracture with radiographic visible trabeculation across the fracture line
2 Failure was seen in 10 patients (22 per cent) This implies recurrence of the fracture deformity This group also includes two cases of failure of the applicance This group does not include avascular necrosis



a anter poster or pos t n *b* lateral pos t on

F g re 9 Ra l ographs of the sl l ng na l plate in a femoral neck fracture

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Number of deaths before follow up	–	–	1	2	7	2	12

the reduction was made under general anaesthesia on the fracture table with fluoroscopy and image intensifier

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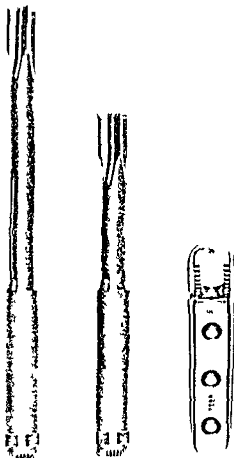


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and definitely not above or anterior to the midpoint of the articular surface of the capital fragment This steep position of the nail also minimizes the strain on the junction between the nail and the plate, and thus we have only seen failure of the appliance in two (3 per cent) cases where the nail slid back into the barrel followed by redisplacement of the fracture Neiminen (1975) reported sliding outwards of the nail in 29 2 per cent and collapse of the junction between nail and side plate in 8 9 per cent in a series of patients treated with early weight bearing

Table 5 Postoperative complications in 65 patients operated with sliding nail plate osteosynthesis for medial fracture of the femoral head

Complications	Number of patients
Death within one month	3
Cardiac diseases	5
Pulmonary diseases	7
Phlebothrombosis	0
Decubital ulcer	4
Miscellaneous	7
Deep infection	1
Total	27

If a patient had more than one complication each complication is listed separately All together there were 21 patients with postoperative complications

In the present study of elderly patients we aimed at a very early mobilization As reported earlier (Brown & Abrami 1964, Graham 1968, and Neiminen 1975) weight bearing 2 weeks after the operation does not deteriorate the final result On the contrary, results indicate that early weight-bearing improves the final result compared with late weight bearing (after 12 to 14 weeks) Investigations by Skipper (1975) show that the first days after the operation the patients only put a little of their body weight on the operated leg, but within a week the ability to bear weight increases rapidly in patients with medial fractures of the femoral neck After an average period of 53 days the patients put full weight on the operated leg

One might expect that the early mobilization with weight-bearing would be followed by an increased incidence of non-union of the fracture and avascular necrosis of the femoral head This has not been the case We found that the rate of union was 94 per cent in stage 3 fractures and 61 per cent in stage 4 fractures

As seen in Table 6, these figures do not differ from results reported earlier (Garden 1961, Brown & Abrami 1964, Graham 1968 Nieminen 1975) Further, they are also in agreement with reports from Odense University Centre (Jensenius

Table 6 Survey of follow up studies after operative treatment of medial fractures of the femoral neck

	Union (per cent)		Avascular necrosis (per cent)	
	Stage 3	Stage 4	Stage 3	Stage 4
Garden 1961 (1)	93	57	29	12
Brown & Abrami 1964	90	65	21	30
Graham 1968	85	71	28	28
Nieminen 1975 (2)	66	65	16	26
Present study	94	61	24	18

(1 Low angle Küntscher nail.
2) Smith Petersen nail with or without side plate

Table 2. Results of the follow-up related to degree of fracture displacement

Displacement	Number of patients	Union	Failed	Doubtful union	Avascular necrosis
Stage 3	18	17	–	1	4
Stage 4	28	17	10	1	3
Total	46	34	10	2	7

Table 3. Results of the follow-up related to the quality of reduction

Reduction	Number of patients	Union	Failed	Doubtful union	Avascular necrosis
Good	38	29	7	2	7
Fair	6	5	1	–	–
Poor	2	–	2	–	–
Total	46	34	10	2	7

Good Reduction is anatomical or slightly in valgus without any rotation
Fair Reduction is anatomical or slightly in valgus with some rotation
Poor Reduction is in varus or with severe rotation

Table 4. Results of the follow up related to the position of the sliding nails

Position of sliding nail	Number of patients	Union	Failed	Doubtful union	Avascular necrosis
Good	26	23	3	–	2
Fair	12	8	4	–	4
Poor	8	3	3	2	1
Total	46	34	10	2	7

Good The nail is placed in the centre or in the lower posterior quadrant of the femoral head
Fair The nail is placed in the lower anterior quadrant or in the superior posterior quadrant of the femoral head
Poor The nail is placed in the superior anterior quadrant of the femoral head penetrating the femoral head, or more than one centimetre below the cortex of the femoral head

and the fracture surfaces could no longer be brought into contact

DISCUSSION

The present sliding nail-plate osteosynthesis differs in only one major respect from other appliances (Pugh 1955, Massie 1958, Brown & Abrami 1964, Ainsworth 1971), it has no fixed nail-plate angle. The fact that the nail is connected by a topbolt to the side plate increases the possibility of obtaining an optimal position of the nail. Backman (1957) showed that the weight-bearing forces which act on the proximal end of the femur are almost vertical, and accordingly we aim at the steepest possible position of the nail resting on the calcar

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QUANTITATIVE HISTOLOGIC ANALYSES OF ARTICULAR CARTILAGE AND SUBCHONDRAL BONE FROM OSTEOARTHRITIC AND NORMAL HUMAN HIPS

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Twelve femoral heads (two normal, four after fracture and six osteoarthritic) were obtained at surgery or autopsy Circumferential slices were obtained and five separate areas were analyzed in each for ash content, histological histochemical grading of the severity of the cartilage changes and quantitative morphometric analyses to establish the percentage of trabecular area, osteoblastic area and osteoclastic area Analyses were performed to compare weight bearing and non weight bearing areas of the femoral heads and to determine correlations between the bony and cartilaginous alterations The data obtained showed wide variations in all parameters in the osteoarthritic specimens but consistently more marked cartilage and bony changes in the weight bearing areas Bone structures and metabolic parameters were distinctly increased for the osteoarthritics, differing significantly from both normal and fracture control groups The bony change correlated directly with the severity of the cartilage lesions, as determined by the histological histochemical grade

Key words bone mineral, cartilage degeneration, osteoarthritis, osteoblastic area, osteoclastic area, subchondral bone, trabecular bone area

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Over the years, numerous reports have described the structural abnormalities in cartilage and subchondral bone from osteoarthritic human joints (Collins 1949 Harrison et al 1953, Sokoloff 1969, Meachim & Fergie 1975) Alterations in these tissues have been shown to be progressive with advancing disease and highly focal, particularly for the femoral head (Mankin et al 1971), the site most extensively studied in recent years Cartilage alterations consist of erosion, ulceration, fibrillation and progressive destruction leading to complete loss of tissue (Collins 1949, Sokoloff 1969, Meachim & Fergie 1975) while the bony changes are those of increased bone formation, thickening trabeculae, sclerosis and cyst formation (Sokoloff 1969, Radin et al 1970, Foss & Byers 1972, Jeffrey 1973) Although the concept of a relationship between the changes in the cartilaginous and bony tissues exists, it ap-

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Dr Reimann served as a Research Fellow in the laboratory under a grant from Henrik and Emilie Gresen Foundation

1956, Frederiksen et al 1967) It also appears from Table 6 that the rate of avascular necrosis in our material was 24 per cent in stage 3 fractures and 18 per cent in stage 4 fractures, and even here the results do not differ

Furthermore, it is evident from Table 6 that there is a high rate of union in stage 3 fractures and a considerably lower rate of union in stage 4 fractures On the other hand, there is no connection between avascular necrosis and the fracture stage

In the present study there was no clinically observed phlebothrombosis or pulmonary embolism, which, together with the low mortality (three patients within 30 days), we attribute to the early mobilization of the patients

As stated by Spotoft (1944) and Garden (1961, 1971, 1974), an exact reduction of the fracture is the basis of a high rate of union (Table 3) That an optimal internal fixation is also of importance in this respect can be seen from Table 4

The conclusion made from this study can only be of a tentative nature due to the small number of patients, but the advantages already mentioned together with the high rate of acceptable results make it an attractive method of internal fixation of medial fractures of the femoral neck

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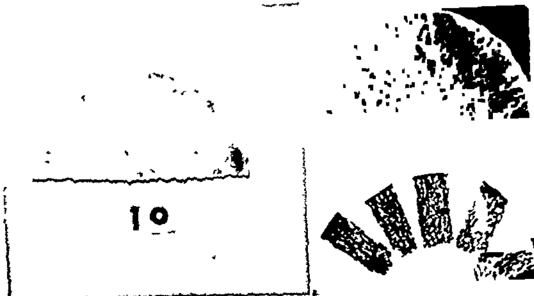


Figure 2 Slice from the normal femoral head of a male aged 61 (left) The x ray shown in the right side of the figure shows the distribution of the bone segments

evaluated by specialized morphometric techniques

The morphometric techniques utilized for this study were designed to provide a measure of total bone present (trabecular bone area per centage of trabecular bone per total area) anabolic activity (osteoblastic area per cent of total bone surface occupied by osteoblasts) and catabolic activity (osteoblastic area per cent of total bone surface occupied by either osteoclasts or resorption lacunae) The trabecular bone area measurement utilized a point counting method with an integrating eyepiece of 22 points in an hexagonal lattice according to the method of Harris & Weinberg (1972) For the osteoblastic and osteoclastic area counts an integrating eye piece with a square lattice was used according to the technique of Melsen et al 19 5) Values were expressed as percentage of total area for trabecular bone and percentage of bone present for osteoblastic and osteoclastic areas

RESULTS

1 Alterations in the cartilage

As can be seen from examination of Table 1 the histological histochemical grades varied considerably from site to site in the five segments studied from each femoral head, particularly in the osteoarthritic group A total of seven of the segments from this group had osteoarthritis of such severity that no cartilage was present on the specimen All of these were in the weight bearing areas

Table 2 shows the mean values for the histological histochemical grading of cartilage from the three groups and a comparison of the values for the weight-bearing and non weight bearing areas *It should be noted* that the bare areas were excluded from the calculations since the grading system provides no score for total loss of cartilage Despite this the differences between the osteoarthritic and either normal or fracture group are significant at the $P < 0.001$ level The fracture group also differed *significantly* from the normal, but with considerably less deviation Only the osteoarthritic group showed a difference between weight bearing and non weight-bearing areas ($P < 0.01$)

2 Mineral content

The distribution of the per cent of mineral content in relation to disease and site is shown in Table 3

pears to be based principally on biomechanical considerations (Radin et al 1973, Pugh et al 1974) To date, no attempt has been made to assess the two processes simultaneously by quantitative histological techniques

In 1971 a report from this laboratory described a histological-histochemical grading system which provided numerical values for defining the severity of the changes in articular cartilage from osteoarthritic femoral heads (Mankin et al 1971) Progressive deterioration provided increasingly higher scores on the scale, and these data correlated well with biochemical (Mankin et al 1971) and enzyme (Ehrlich et al 1973) abnormalities in the cartilage The system does not measure changes in the subchondral bone, and no such grading system for the bone is available

This report describes an experiment which sought to develop morphometric techniques to assess the alterations in subchondral bone and then apply both these and the previously described cartilage grading system to a series of control and osteoarthritic femoral heads Furthermore, it also assesses the variation in the morphometric parameters from site to site and also compares these for osteoarthritic tissue as well as for the normal groups

MATERIAL AND METHODS

Twelve femoral heads were used for this study and divided into three groups A normal group consisting of two femoral heads obtained at autopsy from two male patients aged 60 and 61 a fracture group consisting of four femoral heads obtained at the time of replacement surgery, which took place immediately after the fracture from female patients with an average age of 79 5 and an osteoarthritic group consisting of six femoral heads obtained at the time of replacement surgery from four female and two male patients with an average age of 57 8 Specimens were fixed for 24 hours in 10 per cent buffered formalin phosphate and then two circumferential slices were cut at



Figure 1 Demonstration of the use of the band saw to cut parallel circumferential sections of the femoral heads

exactly 1 5 mm in thickness using a Bronwill TSM 77 band saw (Figure 1) The sections were taken in such a way as to include both weight bearing and non weight bearing areas At the time they were obtained they were photographed and microradiographs were made using a Machlett apparatus (exposure time one hour at 20 KV and 20 MA) Five equally sized rectangular slices were obtained from each section in a manner so as to include both weight bearing and non weight bearing areas (Figure 2)

The five sections from one of the two circumferential slices were used to determine mineral content The samples were fixed in 80 per cent ethanol with three changes over a period of 48 hours After freeze drying at —50° C for three hours the bone pieces were weighed and then ashed at 600° C for 18 hours and reweighed using a microbalance

The second group of five sections was fixed in 10 per cent buffered formalin phosphate then decalcified dehydrated and embedded in paraffin Samples were cut at six micra and stained with hematoxylin and eosin and Safranin O iron hematoxylin fast green for histologic study (Mankin et al 1971) The degree of cartilage degeneration and destruction was evaluated for each of the five segments from the Safranin O stained preparations according to the histological histochemical grading system of Mankin et al (1971) Four microscopic areas of the subchondral bone from each of the five samples were randomly selected for study Two of these were considered to be at the surface and the other two lay one lattice depth subjacent to that region (deep) In all a total of 240 areas were

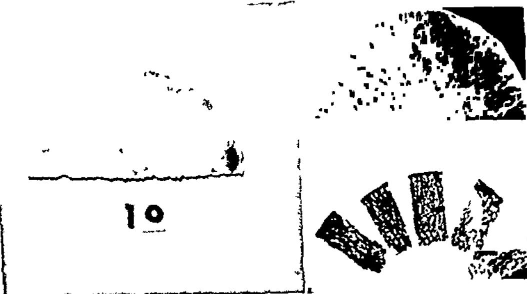


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RESULTS

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2 Mineral content

The distribution of the per cent of mineral content in relation to disease and site is shown in Table 3

Table 1 Distribution of the histological histochemical grades in the cartilage with relation to age sex diagnosis and area

Specimen No	Age	Sex	Diagnosis	Histological histochemical grade WB	Non WB
2	66	F	Osteoarthritis	– –	3 8
4	65	F	Osteoarthritis	13 8 8	5 4
5	46	M	Osteoarthritis	5 5 7	4 2
7	59	F	Osteoarthritis	– – 12	1 2
9	59	F	Osteoarthritis	12 12 –	13
11	52	M	Osteoarthritis	6 13 13	2 13
3	73	F	Fracture	0 2	3 2 7
6	78	F	Fracture	1 4 1	1 2
8	82	F	Fracture	2 3 2 4	5
12	85	F	Fracture	2 2 2	2 2
10	61	M	Normal	0 2 2	0 1
13	60	M	Normal	0 1 2	0 1

– No cartilage remaining

Table 2 Variation of histological histochemical grade with diagnosis and site

	All sites	Weight bearing	Non weight bearing
Normal (10)	0.90 ± 0.88	1.17 ± 0.98 (6)	0.50 ± 0.58 (4)
		n s	
Fracture (20)	2.45 ± 1.57	2.08 ± 1.16 (12)	3.00 ± 2.0 (8)
	$P < 0.001$°	n s	
OA (23)	7.30 ± 4.51*	9.50 ± 3.[illegible]9 (12)	5.18 ± 4.31 (11)
	$P < 0.001$ $P < 0.001$	$P < 0.01$	

* Excludes 7 of 16 sites on the weight bearing areas of the osteoarthritic femoral heads which were bare of cartilage
+ Standard deviation
° As determined by Student's t test

As can be noted the osteoarthritic samples showed a significant ($P < 0.001$) increase in ash content compared with either normal or fracture groups Differences between weight bearing and non weight bearing areas for the normal and fracture groups were just barely significant ($P < 0.02$ and $P < 0.10$ respectively) but for the osteoarthritic subchondral bone it was highly significant ($P < 0.005$) The difference between the ash content of the non weight bearing areas was moderate (a 17 per cent increase in the osteoarthritic group over the other two at the 10 per cent confidence level) but marked in the weight bearing areas (~ 27 per cent increase for the osteoarthritic group with $P < 0.005$)

Table 3 Variation of percentage mineral content with disease and site studied

	All sites	Weight bearing area	Non weight-bearing area
Normal (10)	30 42 ± 4 03*	32 72 ± 2 64 (6)	26 99 ± 3 27 (4)
		$P < 0.02$	
Fracture (20)	29 39 ± 4 64	31 16 ± 4 15 (12)	26 99 ± 4 71 (8)
	n s*	n s	n s
		$P < 0.10$	
OA (30)	38 78 ± 7 54	40 69 ± 10 01 (19)	31 82 ± 5 71 (11)
		$P < 0.005$	
	$P < 0.001$*	$P < 0.005$	$P < 0.10$
	$P < 0.001$†	$P < 0.001$	$P < 0.10$

* Standard deviation
* Significance of variation from the control group as determined by Student's t test.
† Significance of variation from the fracture group

Table 4 Comparison of morphometric parameters for surface and deep zones

	Per cent trabecular bone area	Per cent osteoblastic area	Per cent osteoclastic area
Normal (10			
Surface	20 45 ± 2 22†	24 32 ± 2 53	1 45 ± 0 82
Deep	19 63 ± 3 60	20 28 ± 4 80	1 59 ± 0 63
Fracture (20)			
Surface	16 14 ± 4 61*	22 53 ± 12 10	3 34 ± 1 21*
Deep	16 02 ± 3 51*	20 29 ± 12 52	3 23 ± 1 39*
OA (30)			
Surface	32 58 ± 10 97**	44 20 ± 13.84**	4 21 ± 2 06*
Deep	26 29 ± 8 20**	31 60 ± 8 98**	3 64 ± 1 73*

† Standard deviation
* Indicates significant difference between deep and superficial zones (as determined by a

3 Bone morphometric analyses

In Table 4 all three morphometric parameters for both superficial and deep zones are compared Table 5 shows a comparison of the weight-bearing and non-weight-bearing areas for the same measurements

(a) Per cent of trabecular bone area A significant decrease was noted in the per cent of trabecular bone area in the fracture population compared with the controls, presumably reflecting the fairly marked difference in average age of the two groups and sex variation (see below) This is perhaps an indication of the sensitivity of the method since it is possible to detect the small difference in bone density associated with aging

Table 5 Variation in morphometric parameters for surface and deep zones in weight bearing and non weight bearing areas

	Per cent trabecular bone area		Per cent osteoblastic area		Per cent osteoclastic area	
	WB	NWB	WB	NWB	WB	NWB
Normal	(6)	(4)	(6)	(4)	(6)	(4)
Surface	20 83 ± 2 24†	19 88 ± 2 18	25 81 ± 1 80	22 09 ± 3 62	1 57 ± 0 78	1 28 ± 0 90
Deep	21 59 ± 1 91	16 82 ± 6 14	22 22 ± 3 16	17 37 ± 7 25	1 51 ± 0 47	1 27 ± 0 88
Fracture	(12)	(8)	(12)	(8)	(12)	(9)
Surface	18 75 ± 5 41	12 22 ± 3 42*	20 85 ± 11 f2	25 04 ± 12 84	3 02 ± 1 11	3 81 ± 1 37
Deep	18 18 ± 3 88	12 78 ± 2 96*	19 04 ± 11 75	22 16 ± 13 67	3 17 ± 1 39	3 34 ± 1 39
OA	(19)	(11)	(19)	(11)	(19)	(11)
Surface	36 97 ± 11 f8	25 00 ± 9 75*	48 44 ± 15 05	36 87 ± 11 72*	5 03 ± 2 32	2 80 ± 1 61*
Deep	29 55 ± 8 78	20 66 ± 7 22*	31 85 ± 8 72	31 16 ± 9 43	3 84 ± 2 13	3 30 ± 1 03

† Standard deviation

* Significant difference between weight bearing and non weight bearing zones as determined by Student's t test with $P < 0 01$

Of greater significance to this study, however, was the rather marked increase (~ 60 per cent) in the percentage of trabecular bone in the osteoarthritic surface zone and the slightly less marked increment for the deeper zone (Table 4) Compared with the fracture group, the osteoarthritics were markedly hyperostotic with an increase of over 100 per cent for the trabecular bone area in the surface zone

Analyses of the differences between trabecular bone areas for the weight-bearing and non-weight bearing areas showed no difference for the normal group but there was a significant increase in the weight bearing area for both the fracture group and the osteoarthritics (~ 50 per cent) (Table 5) In both cases the variation was slightly less marked in the deeper zones

(b) *Per cent of osteoblastic area* The percentage of bony surface involved in osteoblastic activity ranged between 18 per cent and 25 per cent for both normal and fracture groups and appeared to vary little with either the surface or deep zones or the weight bearing and non weight bearing areas (Tables 4 and 5) In contrast, the osteoarthritic subchondral bone showed a marked increase in osteoblastic activity with over 40 per cent of the bony surface engaged in new bone formation This represents a significant variation in relation to both control groups with an almost 100 per cent increase for the surface zone and over 55 per cent for the deep zone (Table 4) The surface zone showed approximately 40 per cent greater activity than the deep zone (Table 4) and the value for the weight bearing area exceeded that for the non-weight-bearing by over 30 per cent (Table 5)

(c) *Per cent of osteoclastic area* The percentage of bony surface involved in osteoclastic activity was very low in all groups and at all sites, ranging from 1 27 per cent to 5 03 per cent The values were least in the normal, *greater in the* fracture and highest in the osteoarthritic group (Table 4) No significant difference was noted between the surface and deep zones for any of the groups and

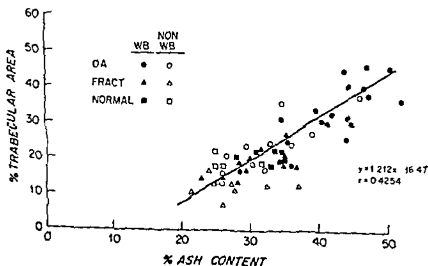


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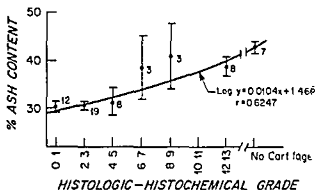


Figure 4. Graphic representation illustrating the relationship between the histological histochemical grade of the articular cartilage and the per cent of mineral content for the osteoarthritic, fracture and normal femoral heads.

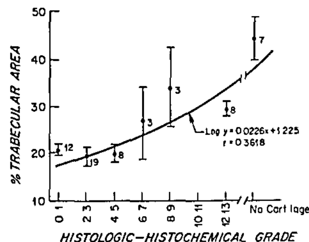


Figure 5. Diagram illustrating the relationship between the histological histochemical grade and the per cent of trabecular area.

only the osteoarthritics showed a difference between weight-bearing and non-weight-bearing areas (Table 5).

4. *Correlations*

As an "internal control" for the methods, the percentage mineral content was compared with the trabecular bone area. As can be noted in Figure 3, the relationship is linear and has a coefficient of correlation of 0.4254. Since only the per cent of trabecular area for the surface zone was included in the calculations (while the per cent of mineral content determination included both the surface and deep zones), this observation serves only as a crude corroboration of the methods.

Of greater importance and central to the theme of the study were the correlative data regarding the histological histochemical grading and the per cent of ash and bone morphometric analyses. Figures 4, 5, 6 and 7 show the correlative data in two forms: groupings with deviations for each data point and correlations as determined by regression analysis. Only the surface morphometric studies were included. As can be seen, the correlations for all but the per cent of trabecular area were of moderate significance. Most

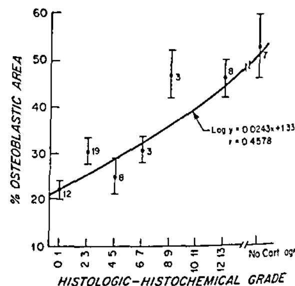


Figure 6. Diagram showing the relationship between the histological histochemical grade and the per cent of osteoblastic area for all specimens.

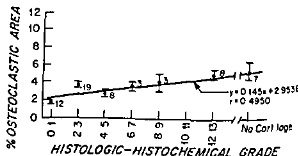


Figure 7. Graphic representation illustrating the relationship between the histological histochemical grade and the per cent of osteoclastic area for all specimens.

closely correlated was the percentage ash content (r = 0 6247) while per cent of osteoblastic and osteoclastic areas were of slightly lesser significance (r = 0 4950 and 0 4578, respectively) The correlations were all non linear except for the per cent of osteoclastic activity

DISCUSSION

Before discussing the significance of the data obtained in this study, it is important to review the methods and some possible sources of error First, in regard to methods, the histological histochemical grading system has been shown to correlate well with biochemical abnormalities in osteoarthritic articular cartilage (Mankin et al 1971) and with increase in enzyme levels in the tissue (*Ehrlich et al 1973*) Its principal value is in providing a technique to evaluate a small locus and hence avoid the problems of the highly focal nature of the osteoarthritic process (Sokoloff 1969) Other methods of classification, especially that of Collins (1949), utilize a more macroscopic approach and are of little value in a study such as this

One problem of the grading system is that no score is possible when the cartilage is totally absent For purposes of determination of the correlation curves in Figures 4 5 6 and 7, an arbitrary value of 16 was awarded to those segments in which no cartilage was found The shape of the curves (and indeed the coefficient of correlation) *might* have been different if another value (such as 20 or 25) had been used

The bone morphometric techniques used in this study are fairly standard and providing they are randomized are considered to be reasonably valid (Harris & Weinberg 1972 Melsen et al 1975) The problem of application to osteoarthritic subchondral bone lies principally in relation to cysts and areas of microfracture Since random-site selection was strictly adhered to and thus no attempt made to preselect non-cystic or non-callus areas, this could in theory have introduced a source of error It should be noted, however, that only the per cent of trabecular area

$$\frac{\text{trabecular bone}}{\text{total area}} \times 100,$$

could be affected by the presence of cysts or fracture callus since the other determinations are based on total bone present This may explain the slightly poorer correlation of the per cent of trabecular bone area observed with the histological-histochemical grade (Figure 5)

As previously noted by Harrison *et al* (1953), variable amounts of osteonecrosis (as determined by empty lacunae) were noted in the subchondral bone of the osteoarthritic specimens, particularly in the weight bearing area Although a presumably important factor in the pathogenesis of the bony changes, the finding *did not* alter the morphometric observations and was not quantified in this study

Two "internal controls" were utilized The first was the inverse correlation of the per cent of trabecular bone area with patient age and sex in the two control groups The two normal femoral heads were from males aged 60 and 61 years, those in the fracture group were all from *females* with an average age of 79 5 On the basis of both sex and age, the fracture group should have been considerably more osteopenic than the controls, and this is clearly evident in the data shown in *Table 4* As a second internal control, the per cent of ash weight was correlated with the per cent of trabecular bone and showed a linear correlation of moderate significance (Figure 4)

One additional problem in the study is related to selection of specimens Although the diagnosis was controlled in the *sense that* the two normal femoral

heads were indeed normal and the osteoarthritics showed extensive changes of disease, the fracture group showed several sites on the femoral heads which displayed mild to moderately severe osteoarthritis Of perhaps greater importance was the fact that sex and age, both of which have a significant effect on bone mass, were not controlled The ages for the three groups differed somewhat (especially the fracture group) and the normal specimens were both from males, in the fracture group all from females, and in the osteoarthritic group from four males and two females For these reasons, the authors utilized the younger, male control specimens upon which to base variations observed in the osteoarthritic group, particularly where a difference was noted between the normal and fracture groups

In consideration of the experimental results, several points are clearly evident First, the histological-histochemical grading of the osteoarthritic cartilage showed wide variation from site to site and more severe changes in the weight-bearing areas These data confirm prior observations from this laboratory (Mankin et al 1971)

Second, the per cent of mineral content and all bone morphometric parameters showed highly significant increments in the osteoarthritic subchondral bone compared with either the control or fracture group Thus, not only is there evidence for a hyperostosis in the subchondral area, but also a fairly profound increase in metabolism reflected by increased rates of both osteoblastic and osteoclastic activity

Of perhaps greater interest was the relationship of these changes to site on the femoral head In all morphometric measurements, the osteoarthritic weight bearing area showed greater increases than the non weight-bearing area with increments above the control values of 27 per cent for ash control 50 per cent for the per cent of trabecular area, 30 per cent for the per cent of osteoblastic area and even greater increments for the per cent of osteoclastic area Furthermore, when looking at the zone extending no more than 5 mm deep to the subchondral surface ("deep" zone), these variations were for the most part significantly reduced These variations with site are consistent with those reported by Foss & Byers (1972), Radin et al (1970 1973), and Pugh et al (1974), but differ from the observations of Lereim et al (1975) who found no significant difference in the density of subchondral bone from the weight-bearing area of osteoarthritic joints and that from the non-weight-bearing area or from normal controls

The principal purpose of this study was to assess if the cartilage changes (which are believed to be an indicator of the severity of the osteoarthritic process) could be correlated with the bony abnormalities as determined by the per cent of mineral content and the morphometric analyses The correlation curves shown in Figures 4, 5, 6 and 7 indicate a direct relationship between the two groups of parameters of moderately high significance ($r = 0.500$) with the exception of the bone trabecular area which correlated less well ($r = 0.4254$) These data define an association between the two biologic processes degeneration of the cartilage and sclerosis and hypermetabolism of the subchondral bone

There are insufficient data from this experiment to indicate whether the two processes, one bony and the other cartilaginous, are related to one another in an etiologic way, as has been suggested by Pugh et al (1974) and Radin et al (1970) or whether the two are responding separately (and oppositely) to some other mechanical or chemical stimulus Although it is possible that the findings are the result of a multiplicity of independent factors the close inverse

concordance allows speculation that the two processes are interdependent and possibly represent two divergent responses to a single biologic alteration

ACKNOWLEDGMENTS

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EARLY AND LATE RESULTS OF BRACKETT'S OPERATION FOR PSEUDARTHROSIS OF THE NECK OF THE FEMUR IN INFANTILE COXA VARA

A Review of 30 Operations

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The early and late results of 30 Brackett operations for pseudarthrosis of the neck of the femur are reviewed The cause of the pseudarthrosis in 28 hips was congenital or infantile coxa vara The patients' ages at the time of the operation ranged from 2 to 43 years The early results were good Only three out of a total of 30 cases failed to unite, 27 hips became stable Necrosis of the femoral head occurred in six hips Late results, on average 13 years after the operation, differed greatly from the early results The majority of the hips were stable but only three completely painless All but four were affected by secondary *osteoarthritis which in six cases was slight*

Key words Brackett s operation, pseudarthrosis of the neck of the femur, infantile coxa vara

Accepted 25 x 76

Brackett & New published their primary results in 1917 The results of the Brackett operation have been reviewed by Brackett (1938), Magnuson (1932, 1940), Rowe & Ghormley (1944), Ivins & Ghormley (1947), and Merle d'Aubigne & Thomine (1968), who treated pseudarthroses following a fracture, whereas Babb et al (1949), Langenskiold (1949) and Pylkkanen (1960) reviewed the results after treatment for pseudarthrosis of the femoral neck in congenital or infantile coxa vara

The purpose of the present study is to ascertain the early and late results of the Brackett operation in non-union of the femoral neck caused by congenital or infantile coxa vara, and also in two chil*dren with non-union of the femoral* neck from other causes The purpose was also to find out whether this operation may still be indicated in certain cases

PATIENTS AND METHODS

From 1945 to 1968 Brackett s operation was carried out at the Orthopaedic Hospital of the Invalid Foundation on 29 patients (14 male and 15 female) *Both hips* were operated on *in one* patient and the total number of hips treated was thus 30 The cause of the pseudarthrosis was coxa vara infantum in 28 hips A two year old child with congenital dislocation of the hip and an eight-year old child with a pseud arthrosis of traumatic origin were also included in the series The patient s ages ranged from 2 to 43 years At the time of the operation 12 of the patients were children A follow up exam

Table 1 Age of patients at operation and at follow-up and duration of follow-up

	Age at operation						
Years	2–9	10–14	15–17	18–19	20–24	25–29	30–34
No of hips	3	2	7	3	8	3	4
	Age at follow-up						
Years	16–19	20 24	25–29	30–34	35–39	40–44	45–61
No of hips	3	3	3	7	5	4	5
	Duration of follow up						
Years	1–4	5–9	10–14	15–19	20–24	25–29	
No of hips	5	4	6	9	3	3	

ination was carried out in the spring of 1972 on a total of 20 hips which were examined both clinically and roentgenologically Running follow up entries with radiographs were available in the hospital records of all of the patients as well as of the 10 patients who failed to attend this particular follow up examination The follow up periods ranged from 1 to 29 years, average 13 years At the time of the follow-up examination or at the last visit to the outpatient clinic, nearly all patients were fully grown (Table 1)

Operative technique

An antero-lateral incision was made in the interval between the tensor fasciae latae and the rectus femoris muscles The joint capsule was incised in line with the femoral neck to reach the pseudarthrosis All dense scar tissue of the non union was excised In the first four operations the freshened cancellous bone surface was placed end to-end *without* excavation of the femoral head The results were not good and therefore in all the other hips the femoral head was excavated to form a concavity or a socket for the distal fragment Next the remnant of the neck was removed and an osteotomy of the proximal part of the greater trochanter with its attached muscles was performed The shaft was inserted as deep into the head of the femur as was possible without breaking the articular surface of the head The word implantation has therefore been used to describe the procedure The greater trochanter was fixed either by a screw or a wire to the upper lateral surface of the femur If necessary the tension of the adductor muscles was relieved by tenotomy performed through a separate incision No metal or bone fixation between the head and shaft of the femur was used

The extremity was immobilized in plaster for 6 to 8 weeks Active mobilization of the limb was commenced thereafter and depending on the degree of consolidation verified roentgenologically, the patient was allowed to start walking one or two months after the removal of the plaster

RESULTS

The series is heterogeneous as regards the patients' ages The age at operation varied between 2 and 43 years, and at follow-up between 16 and 61 years The early results are those which became manifest during the first postoperative year, while those observed after the first year are classified as late results

Early results

No fatal complication occurred On three occasions there was a superficial wound infection Deep thrombosis developed in three instances The consolidation was successful in all three cases

During the operation, the proximal end of the femoral shaft could be placed in a good, central position inside the head on 16 occasions compared with the *upper* part of the head on 10 occasions On four occasions the operation was made without excavating the head

Necrosis of the head was seen one year postoperatively in six hips In three the operation had been made without excavating the femoral head, in two the shaft was in contact with only the upper part of the head, and in one the head, which originally had been well fitted, postoperatively slipped into a bad posi-



Figure 1 a A 17 year old boy Pseudarthrosis of the femoral neck has developed from infantile coxa vara of the right hip The head of the femur is completely detached from the neck but despite considerable decalcification its articular cartilage is smooth and its shape is normal Clinical investigation showed that Trendelenburg s sign was decidedly positive the patient had a bad limp and mobility of the hip was greatly restricted Owing to pain in the hip the patient was only able to do light work



Figure 1 b Brackett s operation was performed 18 months later The radiograph was taken 6 weeks postoperatively The femoral shaft is well implanted and fitted into the head of the femur



Figure 1 c Radiograph taken 18 years after Brackett s operation The patient now 36 years old is a labourer The hip is tender on exertion and has become stiffer but Trendelenburg s sign is negative The femoral head is flattened in shape and incipient slight osteoarthritis is visible



Figure 11 Axial radiograph taken 18 years after operation In this direction the shape of the head is very good

tion In only one case of necrosis of the head did the osteosynthesis fail to consolidate

Initially the overall mobility of the hips diminished in 19 and remained unchanged in 11 cases Ten of those who retained mobility shared the following features a good implantation was reached at the operation it still remained good postoperatively and union was soon established Preoperatively nine patients had an *extension deficit* of a minimum of 30 and a maximum of 60 degrees These deficits were eliminated by the Brackett operation

Length differences between the two legs ranged preoperatively from 2 to 7 cm In only four patients were the legs of equal length The operation increased the difference in lengths in 10 patients by 1 to 3 cm and reduced it in 10 by 1 to 5 cm in the others the difference remained unchanged

Preoperatively, Trendelenburg's sign was positive in all pseudarthrotic hips Postoperatively it was negative in all those in which the osteotomy had consolidated, and positive only in three hips that did not unite (Table 2)

Table 2 Early and late results after Brackett's operation

	Early results	Late results¹)
Trendelenburg's sign		
markedly positive	3	3
slightly positive		6
negative	27	16
Pain		
at rest		14
in walking	9	8
none	21	3
Arthrosis		
marked	–	15
slight		6*)
none	30	4*)

¹) Five patients were followed up from 1961 to 1964 and 20 in 1972 whereas five patients were not seen after 1957 and the late results of these are not known

*) All patients without osteoarthritis and half of the patients with slight osteoarthritis were under twenty-one years of age at the time of the operation

Late results

The majority of the patients of these series treated with the Brackett operation had been followed up in 1957 (Pylkkanen 1960) Five patients were subsequently re examined from 1961 to 1964 and 19 patients with 20 treated hips in 1972 Only four patients had no osteoarthritis and one had an ankylotic hip All patients with osteoarthritic hips suffered from pain on exertion and two thirds of these had pain even at rest Yet Trendelenburg's sign was markedly positive in only three non union hips, slightly positive in six hips and the rest of the hips were stable

As a result of secondary osteoarthritis



Figure 1 a A 17 year old boy Pseudarthrosis of the femoral neck has developed from infantile coxa vara of the right hip The head of the femur is completely detached from the neck, but despite considerable decalcification its articular cartilage is smooth and its shape is normal Clinical investigation showed that Trendelenburg's sign was decidedly positive, the patient had a bad limp and mobility of the hip was greatly restricted Owing to pain in the hip the patient was only able to do light work



Figure 1 b Brackett's operation was performed 18 months later The radiograph was taken 6 weeks postoperatively The femoral shaft is well implanted and fitted into the head of the femur



Figure 1 c Radiograph taken 18 years after Brackett's operation The patient now 30 years old is a labourer The hip is tender on exertion and has become stiffer but Trendelenburg's sign is negative The femoral head is flattened in shape and incipient slight osteoarthritis is visible

the time the secondary osteoarthritis sets in the patients are older, and it should be anatomically possible to perform a total prosthesis operation on their hips Such an operation has been successfully carried out once, 29 years after the Brackett operation

It is self evident that severe coxa vara cases must be treated by extra articular osteotomy before the development of a pseudarthrosis Union of a pseudarthrosis can be considered impossible to achieve (Johanning 1952) The reconstruction of the femoral neck, once it has disappeared by means of trochanteric osteotomies and bone grafts (e g , those described by Pauwels (1949) and Müller (1971)) is extremely difficult *In certain hips primarily those of children and young adults with long standing pseudarthroses, a good result can be achieved with the Brackett operation*

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the mobility of every second hip had diminished since the 1957 follow-up examination. The hips without osteoarthritis had retained their mobility, and were even more mobile than before the operation.

A feature common to all hips without osteoarthritis was that the proximal end of the femoral shaft had initially been brought into a good, central position inside the femoral head and the consolidation was rapid. The average follow-up period was 18 years. Three of the patients were engaged in heavy manual work, and one went to a high school. At the time of the operation their ages had been 2, 19, 20 and 20 years, respectively.

In five of the hips with slight osteoarthritis a good implantation was achieved, and in only one was the contact of fragments poor. The initial consolidation was good. The average follow-up period for this group was 17 years. At the time of the operation three had been over 20 years, and the others younger.

Whatever may have been left of the epiphyseal plate, it is removed in Brackett's operation, and the neck of the femur, therefore, cannot be expected to grow *postoperatively. The epiphysis* of the greater trochanter is not destroyed by the operation, and growth could be observed in children; on one occasion a *trochanteric epiphysiodesis had to be* performed. In three children, longitudinal growth of the healthy lower limb was restricted by means of a distal epiphysiodesis of the thigh and/or a proximal one of the leg. On one occasion, a shortening operation was performed. *In children, the growth of the femoral head is of the greatest interest.* In the operation, a cartilaginous femoral head comprising only a little cancellous bone is implanted on the top of the shaft. Despite this the head can grow moderately and retain a relatively good, almost spherical shape (Figure 1 a, b, c, d).

DISCUSSION

The purpose of this operation must be to obtain a painless, stable and mobile hip without shortening the limb. Is the attainment of such a good result possible?

The procedure is a radical intra-articular operation. It is carried out to repair long-standing pseudarthroses. The method treats the femoral head as if it were a real sequestrum (Brackett & New). The *purpose is to create an* extensive and firm contact between the freshened cancellar bone surface of the femoral head and the proximal top of the shaft, so that vascularization should soon invade the femoral head from the shaft and union take place rapidly.

Owing to the pseudarthrosis, the cartilaginous surface of the femoral head and the articular socket are probably affected with degenerative changes, and the atrophied head is osteoporotic. Apparently, the shape of the head no longer fully corresponds to that of the socket. This can perhaps remodel itself postoperatively in children but not in adults.

Anatomically, the reconstruction remains deficient. Because of absence of the femoral neck and the displacement due to the *pseudarthrosis it* would not have been possible to preserve the neck by the technique described by Merle d'Aubigné & Thomine (1968).

It is easy *to understand that such a* hip cannot withstand decades of strain. A premature osteoarthritis can be expected. It is also evident that the postoperative *mobility of the hip is restricted.* Even the movement of the pseudarthrosis is "lost". However, the hip becomes painless and stable, and the limb is not shortened.

Prosthetic replacement cannot be recommended for children and young adults of working age. The Brackett operation helps the patient to get along for some twenty years, and in some cases a permanently good result is obtained. By

days before and 3 months after the operation Pressure measurements were performed according to Arnoldi et al (1971)

All patients included in this series had a preoperative femoral head pressure over 40 mmHg and/or a femoral neck pressure over 30 mmHg The preoperative mean pressure in the femoral head was 59 9 mmHg (range 48 8–85 1) and the mean pressure of the femoral neck was 44 3 mmHg (range 16 2–79 0) (Table 1) At the follow up investigation 3 months after operation 2 patients had obtained complete relief of rest pain and the other 6 reported partial relief of rest pain (Table 1) The postoperative pressure recordings in the femoral head and neck showed a mean reduction of 9 7 mmHg for both measurement sites This difference is significant at the 5 per cent level (Wilcoxon s signed rank test) The mean reduction was 8 9 mmHg in the femoral head and 10 4 mmHg in the neck These reductions for each site alone are not statistically significant at the 5 per cent level

Radiographic method

Intraosseous phlebography was performed through one of the needles previously introduced for pressure measurements in the femoral head and neck Two ml of the contrast medium Isopaque Cerebral (Nyegaard & Co) was injected manually at an even rate In the preoperative investigations the injection time in 4 patients was 30 seconds In the other 4 patients the injection evoked a reaction of moderate or intense pain and the injection time had to be extended to a maximum of 70 seconds In the postoperative investigations one injection was performed in 45 seconds because of pain and the other 7 were performed within 30 seconds each A tube (Bi 150/30/50 R Siemens) with a focus of 0 6 mm × 0 6 mm was used The focus film distance was 90 cm An AOT film changer (Elema Schönander) with high speed intensifying screens was used The films (Rapid R 100 FW Ilford) were exposed with the patient in the supine position using 70 to 75 kilovolts and 400 milliamps with an exposure time of 0 16 seconds Only anterior posterior series were done

The first film was taken immediately after injection of the contrast medium and further films were exposed every 5th second during the first minute every 15th second during the 2nd and 3rd minute then every 2nd minute for 12 minutes and finally every 5th minute for 15 minutes Thus the exposure program ran for 30 minutes All phlebographic examinations were done immediately after previous pressure recordings In the postoperative investigation an attempt was made to position needles as closely as possible to the same points as prior to operation

The phlebograms were assessed with regard to the drainage pattern and drainage time of the injected contrast medium The drainage pattern shows the distribution of contrast outflow between intramedullary sinusoids (Figure 1) and extraosseous veins (Figure 2) from the neck or head of the femur The extent of drainage through these channels was recorded The outflow through different extraosseous veins was not studied in detail

The drainage time was taken as the number of minutes elapsing between the injection of contrast medium and the first film obtained completely free of visible contrast medium Pooling of contrast medium around the tip of the needle was ignored The drainage time was recorded separately for the intraosseous vessels and extraosseous veins

RESULTS

Before the operation, 7 patients showed pathological phlebograms with a more or less distinct intramedullary drainage pattern (Figure 1) The postoperative drainage patterns were mainly unchanged compared with the preoperative ones in 5 patients (Table 1) Two patients (Nos 3 and 4) showed a more pronounced intraosseous drainage pattern after the operation and one became more extraosseous (No 2)

The preoperative drainage time from the intraosseous space was over 6 min in 6 patients (Table 1) In 5 patients an increase in intraosseous drainage time was recorded postoperatively The time for visible contrast in extraosseous veins remained essentially unchanged (Table 1)

DISCUSSION

The level of the intraosseous pressure in the femoral neck in the nonarthrotic hip has been reported by Arnoldi et al in 1971 (mean 18 7 mmHg, range 12 9–23 5 mmHg, *n* 11) The normal pressure in the greater trochanter was reported by Arlet et al in 1968 (mean 17 2 mmHg,

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THE EFFECT OF FENESTRATION ON INTRAOSSEOUS DRAINAGE IN OSTEOARTHRITIS OF THE HIP

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Eight patients with osteoarthritis of the hip, rest pain and intraosseous hypertension of the proximal femur obtained ameliorated rest pain and reduced intraosseous hypertension 3 months after a fenestration operation in the region of the greater trochanter They were investigated with intraosseous phlebography of the proximal femur Six patients showed delayed intraosseous drainage and 7 had altered patterns of drainage before the operation Three months after the operation the phlebograms showed an even more prolonged drainage time However this difference was not of a statistically significant magnitude Drainage patterns remained mainly unchanged

Key words fenestration, intraosseous phlebography, intraosseous pressure, osteoarthritis

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In osteoarthritis of the hip, venous drainage from the proximal part of the femur is delayed and often shows an altered pattern with dilated intraosseous vessels and diaphyseal sinusoids (Phillips 1966, Arnoldi et al 1972) Arnoldi et al (1971) considered venous engorgement with stasis and intramedullary hypertension to be a probable cause of the rest pain frequently present in this disease After osteotomy with subsequent relief of rest pain, a "normalization" of the intraosseous blood drainage has been reported by Phillips et al (1967) Recently one of the authors (Åström, to be published) found a significant reduction of the elevated intraosseous pressures in the proximal femur and amelioration of rest pain 3 months after a fenestration operation in the region of the greater trochanter in patients with osteoarthritis of the hip

The aim of this study was to investigate whether or not amelioration of rest pain and reduction of increased intraosseous pressure in the proximal femur in osteoarthritis of the hip was associated with normalization of routes and speed of intraosseous drainage

PATIENTS AND METHODS

Eight patients (3 women and 5 men with a mean age of 56 and an age range of 35–72) suffering from osteoarthritis of the hip were selected for this investigation using the criteria of intraosseous hypertension as defined below and rest pain as a dominating symptom They underwent a fenestration operation in the trochanteric region (Åström 1975) Intraosseous pressure measurements in the femoral head and neck were performed under local anaesthesia a few



Figure 1 (Patient No 8) Preoperative phlebogram (25 sec after injection) demonstrating drainage mainly or all by intramedullary sinusoids (||→) Only a few extraosseous veins (|→) are contrast filled

range 12 26 mmHg n 9) Ficat & Arlet (1972) indicated 30 mmHg as the upper limit of the normal intraosseous pressure in the greater trochanter Arlet et al (1972) have reported measurements of the intraosseous pressure in the femoral head of normal hips (mean 24 mmHg range 20-30 mmHg n 4) No other investigations of the pressure in normal femoral heads have been found in the literature However in osteoarthritis of the hip the pressure in the head is about 10 mmHg higher than in the neck (Arnoldi et al 1971 Astrom 1975) In accordance with these investigations we have presumed intraosseous hypertension to be present in the proximal femur when the pressure of the head was found to be over 40 mmHg and/or the pressure of the neck over 30 mmHg

Elimination of intraosseous contrast medium in the normal hip was reported to be completed 6 minutes after the injection by Arnoldi et al (1972) and 5 minutes after the injection by Arlet et al (1971) In our material all patients except one exceeded these limits of "normal" intraosseous drainage time

The results of this investigation suggests a more pronounced abnormality of drainage time after the fenestration operation but the difference between pre and postoperative investigations is not significant

Table 1 Intraosseous pressures roentgenological and clinical observations pre and postoperatively in 8 patients with osteoarthritis of the hip undergoing fenestration operations

Patient no	Site of injection	Preoperative observations						Postoperative observations						Effect on rest pain[3])
		Pressure (mmHg)		Drainage pattern		Drainage time (min)		Pressure (mmHg)		Drainage pattern		Drainage time (min)		
		head	neck	E[1])	I[2])	E	I	head	neck	E[1])	I[2])	F	I	
1	neck	62 4	31 0	++	(+)	4	8	57 4	23 4	++	(+)	4	20	+
2	head	85 1	65 0	0	++		48	75 6	43 8	+	+	0 3	20	+
3	neck	61 5	21 0	++	(+)	3	1 5	38 2	20 0	(+)	++	4	25	+
4	head	49 1	16 2	+	+	6	30	59 4	32 3	0	++	–	6	+
5	neck	49 0	49 8	(+)	++	1 5	30	46 9	54 4	0	++	–	>30	+
6	head	57 0	35 7	+	+	3	15	31 6	14 7	+	+	3	25	++
7	neck	48 8	57 0	++	0	15	–	67 5	65 7	++	0	30	–	++
8	neck	65 9	79 0	(+)	++	4	30	28 9	27 9	(+)	++	10	>30	+

F designates extraosseous drainage and I intramedullary drainage

[1]) 0 = no contrast flow visible in extraosseous veins
\+ = drainage partly by extraosseous veins
++ = drainage mainly or all by extraosseous veins
(+) = a few extraosseous veins filled

[2]) 0 = no contrast flow visible in intramedullary sinusoids
\+ = drainage partly by intramedullary sinusoids
++ = drainage mainly or all by intramedullary sinusoids
(+) = a few intramedullary sinusoids filled

[3]) + = less pain postoperatively
++ = no pain postoperatively



Figure 1 (Patient No 8) Preoperative phlebogram (25 sec after injection) demonstrating drainage mainly or all by intramedullary sinusoids (||→) Only a few extraosseous veins (|→) are contrast filled

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		head	neck	E[1])	I[2])	E	I	head	neck	E[1])	I[2])	E	I	
1	neck	62 4	31 0	++	(+)	4	8	57 4	23 4	++	(+)	4	20	+
2	head	85 1	65 0	0	++		48	75 6	43 8	+	+	0 3	20	+
3	neck	61 5	21 0	++	(+)	3	1 5	38 2	20 0	(+)	++	4	25	+
4	head	49 1	16 2	+	+	6	30	59 4	32 3	0	++	–	6	+
5	neck	49 0	49 8	(+)	++	1 5	30	46 9	54 4	0	++	–	>30	+
6	head	57 0	35 7	+	+	3	15	31 6	14 7	+	+	3	25	++
7	neck	48 8	57 0	++	0	15	–	67 5	65 7	++	0	30	–	++
8	neck	65 9	79 0	(+)	++	4	30	28 9	27 9	(+)	++	10	>30	+

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++ = no pain postoperatively

of a lack of reaction to pain as a limiting factor to the rate of injection in their preoperative examination This factor is of great importance since most patients with intraosseous hypertension experience intense pain during rapid intraosseous injection of fluid

Our findings do not support the assumption (which was the original reason for this work) that ameliorated rest pain and decreased intraosseous pressure in the proximal femur after fenestration in osteoarthritis of the hip are associated with a normalization of intraosseous blood drainage in the proximal femur

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Figure 2 (Patient No 1) Preoperative phlebogram (30 sec after injection) demonstrating drainage mainly by extraosseous veins (|→) Some intramedullary sinusoids (||→) are also contrast filled



In their study of venous drainage after osteotomy, Phillips et al (1967) assumed intramedullary hypertension by venous congestion to be the cause of rest pain in osteoarthritis of the hip They found a normalization of venous drainage 12–20 months after intertrochanteric osteotomy and therefore suggested amelioration of pain to be a consequence of the reduced venous congestion In contrast to the observations of Phillips et al, we were not able to record a similar normalization of venous drainage after fenestration in spite of reduced intraosseous hypertension and ameliorated rest pain The results of this study therefore do not support the hypothesis of a causal connection between impaired venous drainage and intraosseous hypertension The discrepancy between the observations of Phillips et al and ours concerning the venous drainage pattern in patients with postoperative amelioration of pain might be explained by the following differences Firstly, there is the difference in the time interval between operation and postoperative phlebography Secondly, there is a difference in anaesthetic technique in the study by Phillips et al who used general anaesthesia in preoperative examinations but local anaesthesia in the postoperative ones, whereas we used local anaesthesia in both preoperative and postoperative investigations This difference in anaesthetic technique also constitutes a possible difference in the speed of injection of contrast medium pre- and postoperatively in the study by Phillips et al because

such as special clothing, changes in operation technique, double surgical gloves, etc. This renders the evaluation of a separate measure like ventilation difficult.

In this paper a bacteriological and epidemiological study will be reported which was undertaken in the operation suite of a department of orthopaedic surgery during operations of total hip replacement. Special attention was given to transmission of infection in connection with operation.

PATIENTS AND METHODS

Patients

One hundred and forty nine patients were subjected to total hip replacement with the Charnley prosthesis from 1972 to 1974. In 14 patients, double sided replacement was carried out. Altogether 163 hip replacements were thus performed. The majority of the patients were over 60 years of age. The number of males and females was about the same. The shortest observation period was one year and the longest three years. For 77 patients the observation period was more than two years.

Bacteriological investigation

During the investigation period routine samples from nose and throat were taken once a week from all operating staff. Specimens were taken from all patients with clinical signs of wound infection and on re-operation.

Prospective study

Eighty four patients were included in a prospective study. On the day of operation samples were taken from the throat, nose, perineum and the skin of the forearm of the patients.

During 77 operations four sedimentation plates were placed in different parts of the operation room. The plates were exposed for eight hours.

Cultural technique

All samples were taken with cotton swabs. Before the skin test was carried out the swab was moistened in peptone water. The swabs were transported in agar slants. Stuart transport medium was used for wound specimens.

Nose, throat and skin specimens were cultivated on sheep blood agar plates only. Perineum specimens were also cultivated on phenol red mannitol agar.

Wound samples were cultivated on blood agar plates with and without gentian violet, on haematin agar, phenolred mannitol agar plates, and on anaerobic blood agar plates with the addition of yeast extract, vitamin K_1 and haemin. The plates were incubated at 37° C and read after 24 and 48 hours. Anaerobic culture plates were observed for five days and culture was performed according to modern techniques (Anaerobe Laboratory Manual 1973).

Sheep blood agar plates were used as sedimentation plates and read after 48 hours incubation. The total number of bacteria and Staph. aureus was determined. The number of bacteria-carrying particles/m³ was calculated from the number found on the sedimentation plates assuming a sedimentation rate of 0.3 m/min (Noble et al. 1963).

Isolated bacteria were verified according to current techniques. All Staph. aureus were phage typed according to Blair & Williams (1961). Resistance to penicillin was determined with the disc diffusion method according to Ericsson & Sherris (1971).

The design of the operation unit

The design of the central part of the suite, i.e., the operation room with surrounding area

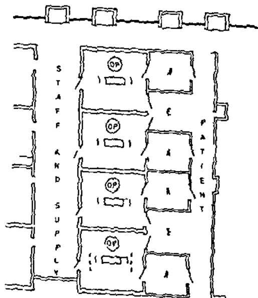


Figure 1. General outline of one block of four operation theatres.
OP. Operation room. The room with the broken line is equipped with zonal ventilation.
A. Anaesthetic room.
E. Exit area.

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AIRBORNE CONTAMINATION AND POSTOPERATIVE INFECTION AFTER TOTAL HIP REPLACEMENT

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The results of 163 hip replacements at the Uppsala University Hospital are presented. Deep infection occurred in ten cases and was caused by Staphylococcus aureus in four early or intermediate infections and by anaerobes in four late infections. The remaining two infections (both of which were late) were probably associated with Staphylococcus albus—in one case possibly also with alpha streptococci. Two superficial infections not affecting the operative result were caused by Staphylococcus aureus and betahaemolytic streptococci. The results of environmental analyses of staphylococci and the total number of bacteria in the air during 77 operations did not indicate that airborne infection is a major cause of postoperative infections—there was no difference between the number of bacteria found in the air during operations after which infection occurred and uninfected operations, and the use of special zonal ventilation with high rates of air exchange in the operating area had no effect on the infection frequency.

Key words: airborne bacteria, arthroplasty of hip, postoperative infection, ventilation

Accepted 23 xi 76

Hospital infections have again been the object of much attention and intensive debate. However, surprisingly *little* is known as yet about the real significance of various ways of transmission and what the most suitable control measures should be.

This subject has been much discussed in orthopaedic surgery, particularly in cases of deep infection after total hip replacement. The frequency of infection varies in different investigations from only a few per cent up to 12 per cent or more (Charnley & Eftekhar 1969, Amstutz 1970, Lindberg 1976). According to Charnley (1972) this infection is mostly airborne and transmission takes place in connection with the operation; in operation suites with conventional ventilation it is hardly possible to have less than four per cent deep infections, but if "ultra clean air" ventilation is introduced it is possible to reduce the incidence to below one per cent (Charnley 1964, 1972, Charnley & Eftekhar 1969, Eftekhar 1973). During the years that Charnley has carried out his tests he has, however, also introduced other protective measures,

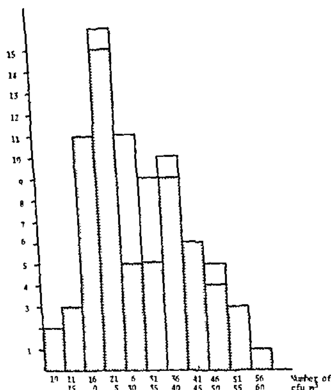


Figure 3 Open bars operations performed in rooms with conventional ventilation Shaded bars operations performed in rooms with zonal ventilation

staphylococci all had different phage patterns

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From the two remaining patients with late infections Staph albus was isolated in one case and Staph albus and alpha streptococci in the other The staphylococci and alpha streptococci in case 10 were isolated on different occasions and their role in the infection is difficult to establish

There were two superficial infections one was caused by betahaemolytic streptococci and engaged the operation wound The infection was treated with V penicillin and healed This patient (case 9) later developed a deep infection The other superficial infection from which Staph aureus was isolated occurred in a pressure wound caused by a plaster cast

B Prospective study

Staff

Staph aureus was isolated from the respiratory tract in 43 per cent of the 169 individuals who took part in operations Phage typing showed that 79 8 per cent of isolated strains were typable Group I was the most common with 40 per cent followed by group III with 18 9 per cent and group II with 15 8 per cent Determination of resistance to penicillin

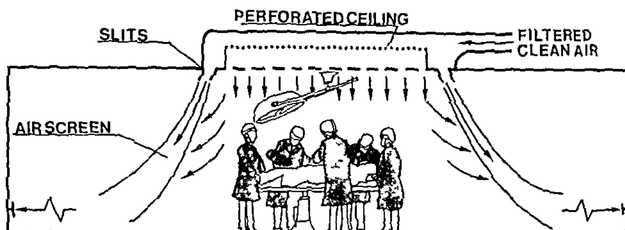


Figure 2 Design of operation room with zonal ventilation

is shown in Figure 1 As can be seen it is a two corridor system in which patients are brought from one of the corridors into the operation room via an anaesthetic room After operation the patient is transferred to an ex tubation area which is shared by two operation rooms and then leaves the unit via the same corridor The other corridor is used by the staff and for incoming clean goods

There are two ventilation systems for the operation rooms One is conventional with up to 18 to 20 changes of air per hour In the other system the main part of the air is introduced above the operation table a so called zonal ventilation (Figure 2) A higher exchange of air is thus achieved—about 80 changes per hour in the central part of the room (Abel & Allander 1966)

Criterion of infection

In addition to bacteriological findings the criteria listed by Ericson et al (1973) have been *considered*

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During the study there were ten deep infections involving the area of pros thesis These cases are presented in *Table 1*

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Table 1 Ten cases of deep infection after total hip replacement

Case no	Sex	Age	Months before sign of infection	Infecting agent	Type of ventilation
1	M	71	0	Staph aureus 6/42E/47/53/54/75/83A	CV*
2	F	65	3	Staph aureus 3 C	CV
3	M	46	2	Staph aureus 29/52	ZV*
4	M	75	6	Staphylococci?	ZV
5	F	74	14	Propionibacterium sp	ZV
6	F	54	10	Peptococcus sp	CV
7	M	70	17	Peptococcus sp	CV
8	M	65	19	Peptococcus magnus	ZV
9	M	63	13	Staph albus	ZV
10	F	44	11	Staph albus? Alpha streptococci?	CV

* CV = Conventional Ventilation
ZV = Zonal Ventilation

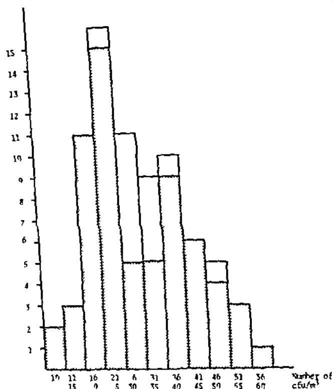


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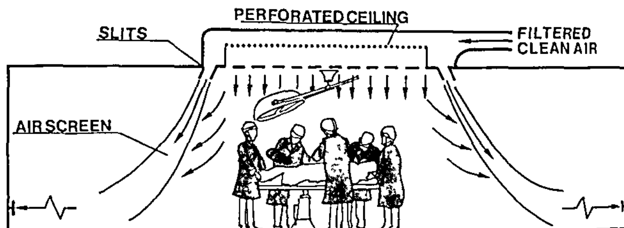


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5	F	74	14	Propionibacterium sp	ZV
6	F	54	16	Peptococcus sp	CV
7	M	70	17	Peptococcus sp	CV
8	M	65	19	Peptococcus magnus	ZV
9	M	63	13	Staph albus	ZV
10	F	44	11	Staph albus? Alpha streptococci?	CV

* CV = Conventional Ventilation
ZV = Zonal Ventilation

ph aureus infection

Patient	Phage pattern of Staph aureus isolated from Staff	Operating theatre	Infection
		29/52	6/42E/47/53/54/75/83A
			3 C
	29/53/80/88	29/52/77	29/52
	52		
	52	NT	
	52/52A		
	52/52A/80		
	NT		
52A/54	29/80	52A/80/54	53/54/77
	6/47/53/54/75/83A	53/54/75	6/47/53/54/75
	3C/55/71	6/47/53/54/75/83A/88	52/52A
	NT		

air in rooms with conventional ventilation No difference was found in the average number of bacteria between operations followed by infection and uninfected operations

The occurrence of Staph aureus was low and it was isolated at only 26 out of *the 84* operations in the prospective study The total number of colonies found during the whole investigation was 44 and not more than three colonies were isolated on one operation day The average occurrence, as estimated from the entire number *of operations,* was *0 08* c f u /m³ air If the mean value is calculated for *operations where Staph* aureus was present, it is shown to be 0 25 c f u /m³ air

Possible transmission routes for infections caused by Staph aureus *were* studied In 13 *operations* Staph aureus with the same phage pattern could be isolated from the environment and from the staff The importance of this with regard to transmission routes in *the four* patients with Staph aureus infections is demonstrated in Table 2 In case *nos* 1 and 2 no preoperative cultures were taken from the patients Among the staff, cultures were taken only from the operating surgeon In case 1 the infection was caused by staphylococci belonging to group III with the phage pattern 6/42E/47/53/54/75/83A The staphylococci isolated from the environment belonged to group I with the phage pattern 29/52 The operator was not a carrier of staphylococci In case 2 the infection was caused by staphylococci group *II* with the phage pattern 3C The surgeon was a carrier of *staphylococci but of another* phage type No environmental investigation was made Case no 3 had a postoperative infection caused by staphylococci group I, phage pattern 29/52 The patient was himself not a carrier of staphylococci Staphylococci with the same phage pattern were isolated from the air during the operation In four out of five of the staff taking part in the operation, staphylococci within group I, with a *similar* phage pattern, were also isolated The total amount of bacteria was 37 *c f u* /m³ air which is somewhat higher than the mean value The amount of staph aureus was 1 c f u /m³ air which is considerably higher than the mean value 0 08 c f u /m³

The superficial infection was a mixed infection with three different types *of* staphylococci The source of one of them was probably the patient, staphylococci *with a* similar phage pattern were isolated from the patient's respiratory tract

Table 2 Four cases of

Case no	Staph aureus, c f u /m³	Total bacteria, c f u /m³	Carriers of Staph aureus	
			Patient	Staff
1	0 13	23	ND*	See text
2	ND	ND	ND	See text
3	1 0	37	No	5
Superficial infection	0 38	28	Nose-throat + perineum	4

* ND = Not Done

showed that 62 per cent of the strains formed penicillinase

Patients

Respiratory tract Staph aureus was isolated from the nose and throat in 22 of the 84 patients, thus giving a carrier frequency of 26 per cent The distribution of strains between the various phage groups was the same as for the staff group Twenty-eight per cent appeared to produce penicillinase

Skin Staph aureus was isolated from the skin of only two patients One of them had a strain of the same phage type on the skin as in the nose/throat, whereas the other patient had non-typable Staph aureus on the skin and typable staphylococci in the respiratory tract

Perineum In eight cases Staph aureus was isolated from the perineum In six of these Staph aureus was also isolated from the respiratory tract, but in two cases they could only be isolated from the perineum One of the patients had the same Staph aureus in the respiratory tract, on the skin, and in the perineum In another two cases the isolated strains were of the same phage type in respiratory tract and perineum, whereas they were of different types in one case Strains from three cases were non-typable

C Environmental investigation
Operation rooms

More operations were carried out in rooms with zonal ventilation than in rooms with conventional ventilation Since some patients had been treated with antibiotics it was difficult to compare infection frequencies among patients operated on under these different conditions Of the patients who were not given any kind of antibiotics, 46 were operated on in rooms with zonal ventilation There were five infections in both groups

Environmental investigation

The results of the analyses of the air from 77 operations included in the prospective study are shown in Figure 3 As can be seen from the figure, the bacterial content was low in both types of operation rooms The highest figure was 56 colony-forming units (c f u) of bacteria/m³, and the lowest 10 c f u /m³ The average total amount of bacteria was 31 c f u /m³ in operation rooms with zonal ventilation, measured outside the highly ventilated area, and 30 c f u /m³

ph aureus infection

Patient	Phage pattern of Staph aureus isolated from Staff	Operating theatre	Infection
		29/52	6/42E/47/53/54/75/83A
	29/53/80/88		3 C
	52	29/52/77	29/52
	52	NT	
	52/52A		
	52/52A/80		
	NT		
52A/54	29/80	52A/80/54	53/54/77
	6/47/53/54/75/83A	53/54/75	6/47/53/54/75
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The superficial infection was a mixed infection with three different types of staphylococci The source of one of them was probably the patient, staphylococci with a similar phage pattern were isolated from the patient s respiratory tract

and perineum as well as from the environment One of the other types had a pattern similar to staphylococci isolated from one of the operating team and from the environment

No attempts were made to isolate anaerobic bacteria from the environment and it has therefore not been possible to establish the ways of transmission for these bacteria The total number of bacteria in one of the anaerobic infections was 42 c f u /m³ which is higher than the mean value In one infection the amount was 24 c f u /m³ air and in two other infections no analysis of the environment were made

DISCUSSION

During the period of study 10 deep infections occurred Four were associated with Staph aureus Anaerobic bacteria probably caused four infections This agrees with the results in some other Swedish reports (Kamme et al 1974) It seems likely that the significance of anaerobic bacteria has been underestimated because of defective isolation techniques

The environmental investigation showed that the occurrence of Staph aureus in the respiratory tract of the staff was 43 per cent which is somewhat above normal, and 29 per cent in patients which is somewhat below normal Phage typing showed that strains within group I were the most frequent among both staff and patients, but no special phage type was predominant The frequency of penicillinase-producing staphylococci was nearly twice as high in the staff group

Air analyses in the operation suites showed that the total number of bacteria was low, the mean was 31 c f u /m³ and there was no difference between the number of bacteria in operations where post operative infections occurred and uninfected operations There was no difference between operation rooms with conventional ventilation and rooms with zonal ventilation In rooms with zonal ventilation the determinations were performed outside the "curtain" We have shown experimentally that the relation between the amount of bacteria outside and inside the zone is not less than 2 1 (Hambraeus et al 1976). This means that the amount of bacteria inside the zone should have been 15 c f u /m³ or less These are low figures and not considerably higher than those found in operation suites with "ultra-clean air ventilation (Charnley & Eftekhar 1969 Cook & Boyd 1971, McDade et al 1968 Scott 1970)

The amount of Staph aureus in the air was very low with a mean value of 0 08 c f u of staphylococci/m³ air In two thirds of the operations no staphylococci were isolated from the air When Staph aureus is isolated from the perineum the risk of transmission is considered to be greater than when it is found only in the respiratory tract At only one of the eight operations, where the patient was a perineal carrier of Staph aureus, was increased transmission to the air established On the basis of these findings the risk of airborne transmission of staphylococci during operation seems small Unfortunately, no attempts were made to isolate anaerobic bacteria in the operation environment It is thus not possible to comment on transmission in these cases

There was no correlation between the amount of Staph aureus in the air and the total amount of bacteria This is in agreement with other reports and confirms the opinion that the total number of bacteria is not a good indicator of the occurrence of possible pathogenic bacteria in the air (Reid et al 1956, Lidwell 1974, Bourdillon & Colebrook 1946)

Phage typing of the staphylococci in the operation room showed that in 60 per cent they were of the same phage types as those carried by the staff in the respiratory tract Only in a few per cent

could the same phage types be found in the patients For 40 per cent of the staphylococci found in the air the origin could not be established This can partly be explained by the fact that the air analyses also covered operations other than those belonging to this study An other explanation is that the staff may carry the staphylococci on their clothes thereby introducing them into the air (Hambraeus et al 1976) A comparatively large number of environmental staphylococci were also non typable

Ventilation does not seem to have af fected the incidence of infection to any great extent as the number of postopera tive infections was the same in patients operated on in rooms with conventional ventilation and in patients operated on in rooms with zonal ventilation However the material is small and does not allow any definite conclusions to be drawn

The investigation showed that there is a need for comprehensive analyses in order to establish transmission In the four staphylococcal infections the way of transmission could be explained in two cases Two were probably airborne and acquired during operation One of these two patients also had an endogenous in fection In two cases the analysis was too incomplete to allow a final estimation of the way of transmission When attempt ing to establish the way of transmission it also seems necessary to study the oc currence of anaerobic bacteria in the operation environment

Neither the results of environmental analyses of staphylococci nor the total number of bacteria found in this study indicate that airborne infection should have been of any great importance for the observed infections In two of the 15 operations where Staph aureus was found in the environment infection oc curred In this respect the results agree with those of other investigators (Shaw et al 1973) but the problem is contro versial and needs further study

Continued and careful tests will be necessary in order to establish the ways of transmission of all bacteria of im portance for these infections and to ob tain a better basis for choosing the best prophylactic methods This is important, especially with regard to the complicated and expensive ventilation systems and other measures that have been intro duced for this kind of surgery

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KNEE INSTABILITY AND TIBIAL OSTEOTOMY

A Clinical Study

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Departments of Orthopaedic Surgery and Diagnostic Radiology
Linkoping University The Medical School Linkoping Sweden

Twenty one gonarthrosis patients were preoperatively assessed according to a newly developed orthoradiographic technique (three point measurement) and followed up for 2–3 years postoperatively using this technique The medio lateral instability of the knee joints was not influenced by the operation The varus/valgus deviation was under corrected on average but the deviation did not increase significantly with time after the operation Judging from this pilot study the three point measurement technique supplies relevant information and it is now being used in a prospective study on high tibial osteotomy in gonarthrosis

Key words knee instability, measurement orthoradiographic method gonarthrosis tibial osteotomy

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Since osteotomy of the tibia was first reported by Jackson in 1958 as a method of treatment for gonarthrosis this operation has gained wide acceptance However preoperatively the size of the wedge to be removed is estimated in many different ways by the various orthopaedic surgeons (Jackson & Waugh 1961 Devas 1969 Harris & Kostuik 1970 Coventry 1973) To get a more precise picture of the instability of the knee joint we have devised an orthoradiographic examination method and tested it on healthy subjects (Edholm *et al* 1977)

This paper describes its use in the preoperative assessment of gonarthrosis patients

METHOD

The orthoradiographic technique was used to examine patients with gonarthrosis before and *after the operation* As the varus/valgus deviation of healthy subjects was found *to be near* zero (Edholm et al 1977) we estimated the *size* of the wedge to be removed so that the deviation after operation would be zero *Thus* the size of the wedge should be the same as the deviation determined by the three point measurement technique *A high* tibial wedge *osteotomy* fixed with *one* or *two* staples was used No special effort was made *to tighten the collateral* ligaments

MATERIAL

Twenty five patients were operated on Three died from causes *unrelated to the* operation and one moved abroad *The remaining* 21 patients (13 women 8 men) *with 23* operated knees were followed up for 2–3 years (mean 32 months) Their ages ranged from 47–77 years

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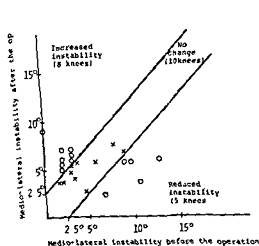


Figure 3 The medio lateral instability of the 23 knee joints before and a short time after the operation ○ = changed and × = unchanged instability

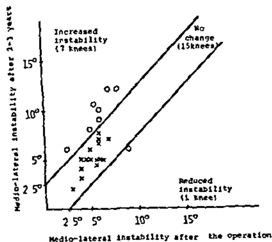


Figure 4 The medio lateral instability of the 23 knee joints a short time and 2-3 years after the operation ○ = changed and × = unchanged instability

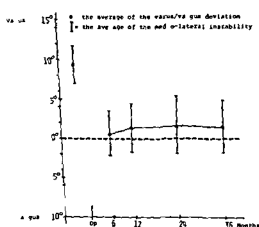


Figure 5 The average of the varus/valgus deviation and the medio lateral instability of the 23 knee joints as they change with time after the operation

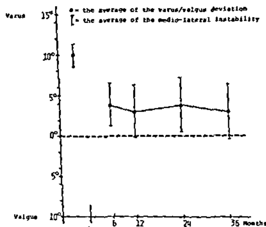


Figure 6 The varus/valgus deviation and the medio lateral instability as they change with time in 10 undercorrected knees (Undercorrected = initial postoperative varus deviation > 2°)

Table 2 The patients overall judgement of the operation

No symptoms after the operation	39 %	78 %
Much better " " "	22 %	
Better " "	17 %	
Unchanged " " "	9 %	
Worse " "	13 %	

part satisfied with the results of the operation (Table 2)

DISCUSSION

With the three point measurement technique we are able to determine the size of the wedge in a standardized way It

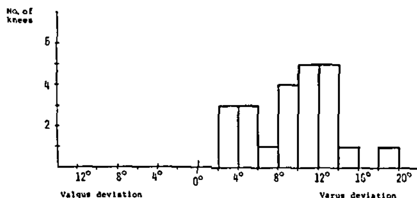


Figure 1 The distribution of the varus/valgus deviation of the 23 knee joints before the operation

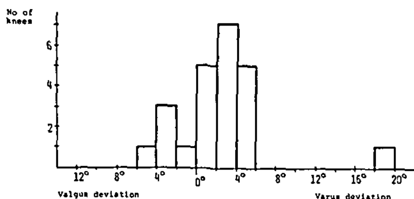


Figure 2 The distribution of the varus/valgus deviation of the 23 knee joints after the operation

(mean 64 years) All the patients had a medial gonarthrosis and thus a valgus osteotomy was done on all the patients

RESULTS

The varus/valgus deviation was corrected in most cases by the operation but one knee was grossly undercorrected (Figures 1 and 2) The medio-lateral instability was as a rule not influenced by the operation (Figures 3 and 4) Taken as an average the varus/valgus deviation was undercorrected and increased slightly with time (Figure 5), but was within the uncertainty factor of the orthoradiographic method One would expect the varus/valgus deviation to increase with time in under- or over-corrected knees (Figures 6 and 7) but this did not occur The pain on loading the knee joint, pain at rest and pain when starting to walk were reduced to various degrees (Table 1) and the patients were for the most

Table 1 Subjective symptoms before and after the operation

Symptom	Before operation	After operation			
		None	Less	Unchanged	Worse
Pain on loading	23 (100 %)	12 (52 %)	6 (26 %)	5 (22 %)	0
Pain at rest	19 (83 %)	18 (78 %)	2 (9 %)	1 (4 %)	2 (9 %)
Pain on starting to walk	20 (87 %)	9 (39 %)	8 (35 %)	3 (13 %)	3 (13 %)

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ARTHROPLASTY OF THE KNEE IN OSTEOARTHRITIS AND RHEUMATOID ARTHRITIS

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147 cases of arthroplasty of the knee were reviewed Three types of prostheses were used viz, St Georg Geomedic and hinge (Shier and Guépar) Pain was the most common indication for the operation which produced complete or almost complete relief in 90 per cent of the cases In half of the joints with a mobility of less than 80 degrees preoperatively, the range of movement was increased to more than 80 degrees by the operation Lack of extension, deformity and instability could be largely corrected Two cases of deep infection were observed both in patients treated with a hinge prosthesis In one of them the complication led to amputation above the knee and in the other to arthrodesis

Key words arthroplasty, knee joint osteoarthritis, rheumatoid arthritis

Accepted 28 x 76

In recent years arthroplasty has been used more often in the treatment of osteoarthritis (OA) and rheumatoid arthritis (RA) of the knee A wide variety of prostheses have been designed and new ones are continually appearing So far however, no ideal type of prosthesis for all cases has been developed, the results of which is that a wide range of indications requires a selection of several types of prostheses This paper reports the indications and results achieved with three different prostheses at the Department of Orthopaedic Surgery in Malmo

PATIENTS AND METHODS

The clinical material consisted of 147 knees of 119 patients operated upon between 1972 and 1975 By the time of the review six patients (seven knees) had died The remaining 113 pa-

had rheumatoid arthritis (RA) The mean age of the former group was 69 years (range 52–83) and that of the latter 62 years (range 43–77) The mean follow up of the former group was 21 months (4 40) and of the latter 16 months (4 44) The types of prostheses used in these patients and the follow up time are shown in Tables 1 a and b The St Georg prosthesis was used only in cases of OA in which the medial, and occasionally the lateral part of the joint was involved (Figures 1 a and b) When the OA had affected the lateral as well as the medial part, and in cases of RA, the Geomedic prosthesis was preferred (Figures 2 a and b) A hinge prosthesis was used (Shiers before March 1973 Guepar after this time) in only those cases with severe instability because of insufficiency of the collateral ligament and/or advanced destruction of the joint (Figure 3 a and b) Recommended

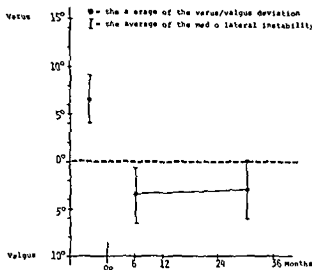


Figure 7 The varus/valgus deviation and the medio lateral instability as they change with time in five overcorrected knees (Overcorrected = initial postoperative valgus deviation > 2°)

also allows us to check the results of our operations in a reproducible way The results in terms of subjective improvement of the patients with about 80 per cent that benefited by the operation, are the same as in most materials on high tibial osteotomy (Jackson & Waugh 1961, Ahlberg et al 1968 Devas 1969, Harris & Kostuik 1970, Appel & Friberg 1972, Coventry 1973 Hagstedt 1974, Insall et al 1974, Seal & Chan 1975) We therefore conclude from this pilot study that the three point measurement technique gives us relevant preoperative information We are now using this method in a prospective study to evaluate the results obtained using different operating principles

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Figure 2 A 46 year old woman with rheumatoid arthritis before and after arthroplasty of her right knee with a Geomedic prosthesis

RESULTS

The effect of the arthroplasty on pain range of movement and deformity was assessed by comparison between the pre and postoperative state of the knee, according to Freeman et al (1973) (Figures 4 5 and 6) Complete or almost complete relief of pain was obtained in 90 per cent of the cases Persistent pain was referable to the patellofemoral joint in most cases Twelve knees in the OA group and 12 in the RA group were excluded from Figure 5 because the preoperative data were insufficient In all these cases except one OA case the postoperative range of movement was 80 degrees or more In those patients in whom the preoperative mobility of the joint was more than 80 degrees this remained the same after the operation In half of the cases in which the mobility was less than 80 degrees it increased to 80 degrees or more as a result of the operation In



Figure 3 A 63 year old woman with rheumatoid arthritis before and after arthroplasty of her left knee with a Guepar prosthesis





Figure 1 A 73 year-old woman with degenerative arthritis before and after arthroplasty of her right knee with a St Georg prosthesis

standard surgical techniques were used (Engelbrecht 1971, Coventry et al 1972 Alnot et al 1971) The operation was performed with a tourniquet above the knee It was removed before the parts of the prosthesis were cemented Suction drainage was used for 48 hours after the operation The leg was placed in a plaster splint for 10 to 14 days The splint was removed a few hours every day to permit exercise of the quadriceps and gentle movement Loading of the leg with the splint was allowed from the second postoperative day To prevent infection the patient was given Ekvacillin® (1 g/day) for the first postoperative week Thromboembolic prophylaxis in the form of 500 ml 6 per cent Dextran 70 was given during the operation and again on the second postoperative day

All the patients were then examined by one (B L) of the authors The examination included both clinical and roentgenologic evaluation of the knee The clinical examination comprised assessment of pain mobility stability and deformity, as well as walking capacity and the patients' opinions of the results of treatment Pain was classified according to Freeman et al (1973) as absent mild (pain which is not spontaneously complained of and which does not require medication) moderate (pain which is spontaneously complained of but which is relieved by simple analgetics) and severe (any other pain) The stability of the joint was examined with the patient in the supine position and the knee slightly flexed Both lateral and sagittal instability were classified as absent moderate or severe Notes were also made of any complications

Table 1 a Types of prostheses

	St Georg	Geomedic	Hinge	Total
Osteo arthritis	40	25	8	73
Rheumatoid arthritis	0	58	9	67
Total	40	83	17	140

Table 1 b Follow up time

Months	St Georg	Geomedic	Hinge	Total
4–12	2	42	4	48
13 24	15	28	6	49
> 24	23	13	7	43
Total	40	83	17	140

Table 2 Patients opinion

	Satisfied	Improved	Unchanged	Worse	Total
Osteoarthritis	45	19	1	8	73
Rheumatoid arthritis	60	5	0	2	67
Total	*105*	*24*	*1*	*10*	*140*

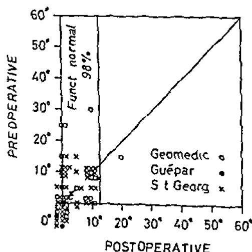


Figure 6 a Flexion deformity Osteoarthritis

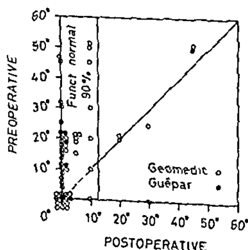


Figure 6 b Flexion deformity Rheumatoid arthritis

preoperative condition of the knees were not sufficient to warrant a reliable comparison between the state of the knees before the operation and at the review

In the RA group, however, both sagittal and lateral instability were predominant and were sometimes severe Those patients with moderate instability at the review had no clinical symptoms since correction of valgus or varus deformity had resulted in a favourable distribution of the weight placed on the joint and the joint had been stable when fully extended The patients' opinions of the results of the operation are given in Table 2

Complications

A 79 year old women died from pulmonary embolism two weeks after the operation The other five deaths occurred long after the operation and were not related to it The local complications are summarised in Table 3

Table 3 Local complications

St G[illegible]

[illegible]

[illegible] infection (antibiotics)

Shiers (6 knees)
1 infection (above knee amputation)
1 loosening of the axes (corrected)

Guepar (11 knees)
1 infection (arthrodesis)

The most common local complication was loosening of the prosthesis which occurred in five cases In all of these it was the tibial part that had loosened

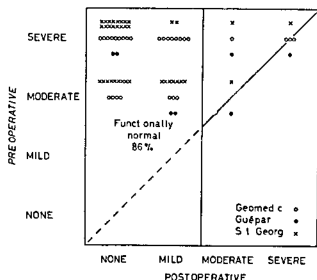


Figure 4 a. Pain. Osteoarthritis.

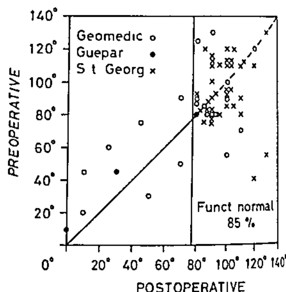


Figure 5 a. Range of movement. Osteoarthritis.

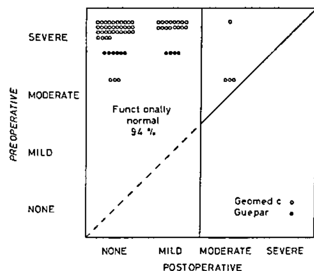


Figure 4 b. Pain. Rheumatoid arthritis.

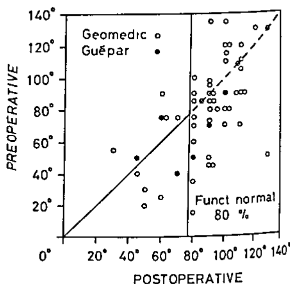


Figure 5 b. Range of movement. Rheumatoid arthritis.

eight cases in which mobilisation of the joint was difficult postoperatively, redressment under anaesthesia was made two to four weeks after the operation. Of greater importance than the total range of movement was the fact that in most of the cases extension defects and deformities could be corrected. This was most obvious in the RA patients, who were often severely disabled preoperatively. In Figure 6, nine OA and four RA cases were excluded because of insufficient preoperative data. None of these cases had any flexion deformity postoperatively.

Moderate sagittal instability occurred in five of the 40 knees treated with a St. Georg prosthesis and in two of the 58 RA knees treated with a Geomedic prosthesis. Moderate lateral instability was noted in 10 and was severe in one of the 40 patients with a St. Georg prosthesis. Of the 25 patients with OA and treated with a Geomedic prosthesis, moderate lateral instability was observed in 10. The corresponding figure for the 58 RA knees was 14, plus four in whom the instability was severe. The data about the

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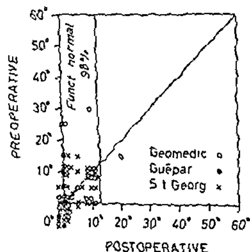


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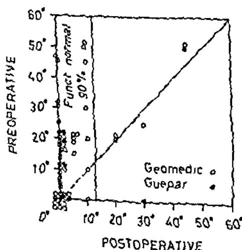


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Table 3 Local complications

St Georg (40 knees)
3 loosening of tibial part (replaced by Geomedic)
2 malposition of tibial part (corrected)
1 suspected infection (antibiotics)

Geomedic (83 knees)
2 loosening of tibial part (replaced by *Guépar*)
1 instability (replaced by Shier)
1 suspected infection (antibiotics)

Shier (6 knees)
1 infection (above knee amputation)
1 loosening of the axes (corrected)

Guepar (11 knees)
1 infection (arthrodesis)

The most common local complication was loosening of the prosthesis which occurred in five cases In all of these it was the tibial part that had loosened

These patients were re-operated upon six months to two years after the primary operation. Deep infection occurred in two patients, both operated upon with a hinge prosthesis. One of these, a 52-year-old man with a Shier prosthesis, required amputation above the knee. The stump healed well and the patient has a prosthesis that functions well. The other patient, an elderly woman with a Guépar prosthesis, had an arthrodesis. Two cases of suspected infection were treated with antibiotics. No signs of infection were seen at the review. Neither rupture of the wound nor marginal necrosis was seen in any of the patients.

DISCUSSION

The different types of prostheses available for replacement of half of the joint are so alike that it seems immaterial which type is chosen. The reason why the Geomedic prosthesis was preferred to the double St. Georg prosthesis was because it was thought to be technically easier to obtain a good fit between two parts than between four. In addition, the Geomedic prosthesis has the advantage that its design prevents sagittal instability and lateral or medial dislocation, an advantage of great importance in the treatment of patients with RA.

The hinge prosthesis was used only in cases of a severe instability and deformity. During the former part of the period covered by the investigation the Shier prosthesis was used, but this was gradually superseded by the Guépar prosthesis which requires less resection of the bone and leaves the patella intact. The hinge prosthesis requires opening of the tibial and femoral medullary cavity and in the event of complicating infection, the prospects of securing arthrodesis are not as good as after the use of other types of prostheses.

The follow-up time was, in about one third of the cases, 4 to 12 months and in about another third more than two years. No significant difference in the results was observed related to period of follow-up time. However, the possibility of further complications such as late infection and loosening must be stressed. All complications observed in this series were diagnosed within 2 years after operation. A direct comparison with other materials is difficult because these usually deal with only one type of prosthesis.

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AMPUTATION AND PROSTHETIC FITTING IN A PATIENT WITH GUÉPAR ENDOPROSTHESIS

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Ischaemic gangrene of the foot in a patient previously fitted with an arthroplasty of the knee (Guepar) was treated with below knee amputation The endoprosthesis was retained and the patient was fitted with a modified PTB prosthesis The functional result is satisfactory

Key words amputation arthroplasty knee joint prosthesis

Accepted 21 xii 6

Knee arthroplasty is an increasingly common operation in routine orthopaedic practice Most of the patients are elderly and one must reckon with the risk that at a later date peripheral circulatory disturbance will necessitate ipsilateral leg amputation

This problem arose in a 34 year old woman with severe chronic rheumatoid arthritis She was virtually confined to a wheelchair until 1970 when bilateral Ring arthroplasty of the hips enabled her to walk with the aid of crutches and to work as a telephonist

Progressive involvement of the knees however produced destruction of the articular surfaces and contactures Once more she became chairbound Bilateral Guepar arthroplasty was therefore performed early in 1975 Remobilization was uncomplicated

About four months after the Guépar operations she was fit to resume work but she wanted to go to Spain on an organized holiday for disabled persons After 2 weeks in Spain she became ill with rapidly developing paralysis paraesthesia and pain particularly in the legs She returned to Sweden and examination at this clinic revealed rheumatic polyneuritis with symmetrical peripheral paralysis and impaired sensitivity

In consultation with rheumatologists the patient was immediately given immunosuppressive agents and cortisone Two days later however signs of peripheral circulatory insufficiency appeared in the left foot and she was transferred to the rheumatological unit Despite energetic measures including pressure chamber therapy the foot became gangrenous and she was returned to the orthopaedic clinic for amputation

The decision to attempt below knee amputation was based on the functional outlook The expected functional handicap was incomparably less than that entailed by an above-knee amputation and the good function in the endoprosthesis indicated favourable prospects for weight bearing and control of the prosthesis In this decision the patient concurred

On November 11 1975 the left lower leg was amputated according to Burgess (1969) The tibia was divided about 16 cm distal to the tibial plateau The mar

These patients were re-operated upon six months to two years after the primary operation Deep infection occurred in two patients, both operated upon with a hinge prosthesis One of these, a 52-year-old man with a Shier prosthesis, required amputation above the knee The stump healed well and the patient has a prosthesis that functions well The other patient, an elderly woman with a Guépar prosthesis, had an arthrodesis Two cases of suspected infection were treated with antibiotics No signs of infection were seen at the review Neither rupture of the wound nor marginal necrosis was seen in any of the patients

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DISCUSSION

Circulatory disturbance with ischaemic gangrene of the foot below a total knee prosthesis may be in future a not unusual combination Below-knee amputation can offer a solution in these cases, provided that the arthroplasty is functioning satisfactorily A relatively long tibial stump must be left to fit under the shaft and cement of the prosthesis, but a dorsal flap should cope with the skin problem in most cases

The reason why this patient was not initially fitted with an ordinary PTB prosthesis with cuff suspension was the fear of excessive strain on the fixation of the endoprosthesis, particularly in lateral and rotatory movements The justification of this decision remains an open question The favourable experience with the bathing prosthesis indicates that the ordinary type might have functioned equally well

In elderly or severally disabled persons, however, relatively little knee function is lost if a PTB is supplemented with double bars and corset Moreover, the discrepancy between the lower-leg prosthesis and the knee function is less than in ordinary amputation cases, since the Guepar prosthesis also has only a simple rotatory axis

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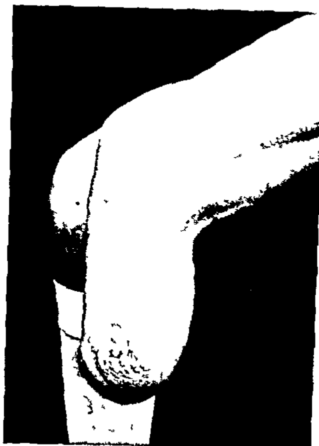


Figure 1 Amputation stump



Figure 3 Roentgenogram of the amputation stump with PTB prosthesis

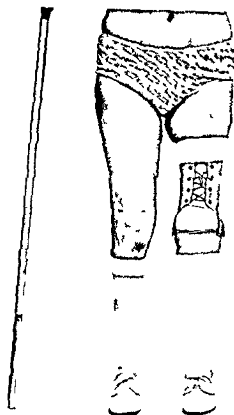


Figure 2 The patient with the prosthesis

row at that point appeared to be normal The amputation wound healed normally within 3 weeks (Figure 1) After 3 more weeks the first prosthesis was fitted It was a combination of PTB with double bar and thigh corset Figures 2 and 3) The right foot was simultaneously fitted with an extension bar to correct persistent foot drop

The patient rapidly became ambulant Aftercare was given at the rheumatologic unit Her general health improved and after some time a light bathing prosthesis of the ordinary PTB type was fitted which enabled her to walk for short distances by the pool At check-up more than 6 months after the amputation she was walking—as preoperatively—with two crutches She had no discomfort from the stump and had resumed work as a telephonist

DISCUSSION

Circulatory disturbance with ischaemic gangrene of the foot below a total knee prosthesis may be in future a not unusual combination Below knee amputation can offer a solution in these cases provided that the arthroplasty is functioning satisfactorily A relatively long tibial stump must be left to fit under the shaft and cement of the prosthesis but a dorsal flap should cope with the skin problem in most cases

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Acta orthop scand 48, 108–114, 1977

REIMPLANTATION OF A TRAUMATICALLY EXPELLED TIBIAL DIAPHYSIS

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The successful reimplantation and healing of a traumatically expelled tibial diaphysis in a 16 year old boy is presented. Radionuclide scintimetry with ^{87m}Sr and ^{85}Sr during the following months showed a pronounced diaphyseal activity corresponding to abundant periosteal bone formation around the dead cortical bone, increased activities over the fractures and the growth plates. Microscopical investigation after tetracycline labelling about 1 year after the accident showed a pronounced osteoblastic and osteoclastic activity in the superficial part of the cortex of the reimplanted bone. The endosteal part consisted of necrotic bone and was only to a small extent replaced by new bone. The uncomplicated healing process observed in this case can be attributed to the youth of the patient, the absence of infection and, most important of all, the preservation of the periosteum and its blood supply.

Key words: bone regeneration, bone resorption, fractures, histology, oxytetracycline, reimplantation, strontium radioisotopes

Accepted 29.xi.76

The management of excessive traumatic loss of cortical bone is a difficult problem. The use of autogenous transplants, artificial devices, as well as reimplantation of expelled pieces of bone (Strange 1963, Kirkup 1965, Abell 1966) has been described. The preoperative handling of expelled bone has also been discussed (Burwell 1969, Imamaliev 1969). However, to our knowledge successful reimplantation of a large, full width piece of the tibial diaphysis has not been reported previously. The reorganization of the reimplanted bone was studied by radiography, scintimetry and microscopy.

CASE REPORT

Clinical course

A boy aged 16 years riding his motorcycle collided with a lorry in December 1973. On admission to a nearby hospital he had a large wound over the right tibia and a 15 cm long piece of expelled tibial diaphysis was found in his trousers. He also had a closed fracture of his right femoral shaft. The initial therapeutic suggestion was to perform an amputation but as the circulation and nerve supply of the limb were intact the surgeons contacted the central orthopaedic clinic. The boy was given high doses of penicillin and tetanus toxoid and the expelled bone was placed in a container with sterile Ringer solution. The boy and the bone fragment were then immediately sent to us, a journey of 1½ hours. On admission here the boy was in good general condition. He had a 25 cm long clean wound on the anterior side of the lower leg and the transverse ends of the tibia could be seen in the proximal and distal ends of the wound. The 15 cm long bone fragment comprised the whole missing part. Radiographs showed absence of the tibial shaft (Figure 1) but intact knee and ankle joints.

An operation was immediately performed. The loose bone fragment was carefully cleaned, replaced and fixed with a Rush pin. The periosteal

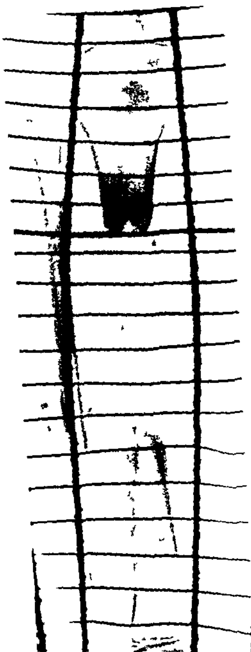


Figure 1 Radiogram on admission Traumatic loss of [illegible] cm of the tibial diaphysis The fractures are transverse Note shortening of the leg as [illegible] with Figure [illegible]

[illegible]be which had ruptured along the entire bone [illegible] was sutured back over the bone After [illegible]sure of the wound the leg was immobilized

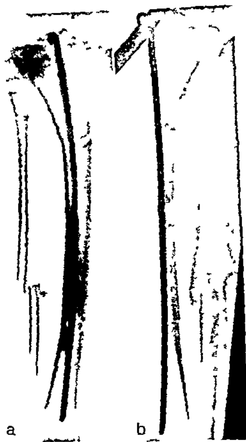


Figure 2 Radiograms 2 weeks after reimplantation and nailing of the expelled tibial diaphysis Early signs of periosteal bone formation

in a plaster Postoperatively a slight valgus deformity (Figure 2) was partially corrected with closed reduction

Ten days after the accident the femoral shaft fracture was operated on and fixed with plate and screws Healing of this fracture was uncomplicated

The postoperative course was remarkably uneventful He received 8 million international units [illegible] penicillin daily for 4 weeks The wounds healed without signs of infection After 6 weeks he returned home After 2 months a PTB plaster was applied (Figure 3) Full weight bearing was allowed after 3 months After 4 months he could walk quite well and he could flex his knee 90° Nine months after the accident knee flexion was quite normal and the boy could run in the forest and play football

One year after the accident there was no difference in leg length and there was normal motion of the knee and ankle joints The fractures had consolidated both clinically and radio-

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REIMPLANTATION OF A TRAUMATICALLY EXPELLED TIBIAL DIAPHYSIS

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Department of Orthopaedic Surgery, University Hospital Lund Sweden

The successful reimplantation and healing of a traumatically expelled tibial diaphysis in a 16 year old boy is presented Radionuclide scintimetry with ^{87m}Sr and ^{85}Sr during the following months showed a pronounced diaphyseal activity corresponding to abundant periosteal bone formation around the dead cortical bone increased activities over the fractures and the growth plates Microscopical investigation after tetracycline labelling about 1 year after the accident showed a pronounced osteoblastic and osteoclastic activity in the superficial part of the cortex of the reimplanted bone The endosteal part consisted of necrotic bone and was only to a small extent replaced by new bone The uncomplicated healing process observed in this case can be attributed to the youth of the patient the absence of infection and most important of all, the preservation of the periosteum and its blood supply

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CASE REPORT

Clinical course

A boy aged 16 years riding his motorcycle collided with a lorry in December 1973 On admission to a nearby hospital he had a large wound over the right tibia and a 15 cm long piece of expelled tibial diaphysis was found in his trousers He also had a closed fracture of his right femoral shaft The initial therapeutic suggestion was to perform an amputation but as the circulation and nerve supply of the limb were intact the surgeons contacted the central orthopaedic clinic The boy was given high doses of penicillin and tetanus toxoid and the expelled bone was placed in a container with sterile Ringer solution The boy and the bone fragment were then immediately sent to us a journey of 1½ hours On admission here the boy was in good general condition He had a 25 cm long clean wound on the anterior side of the lower leg and the transverse ends of the tibia could be seen in the proximal and distal ends of the wound The 15 cm long bone fragment comprised the whole missing part Radiographs showed absence of the tibial shaft (Figure 1) but intact knee and ankle joints

An operation was immediately performed The loose bone fragment was carefully cleaned replaced and fixed with a Rush pin The periosteal







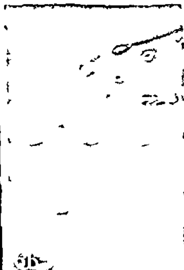






Figure 5 Fluorescence microphoto Undecalcified transverse section from
a) periosteal region
b) middle region and
c) endosteal region of the cortex Note two fluorescent yellow zones indicating bone apposition between the two injections of oxytetracycline
The revitalisation is prominent in the superficial parts (a and b) but almost absent in the deeper part of the cortex (b and c)

Figure 6 Microphoto Decalcified longitudinal section from
a) periosteal region
b) middle region and
c) endosteal region of the cortex Ehrlich's haematoxylin eosin Note necrotic as well as living bone in the superficial regions (a+b) Deeper regions are characterised by almost necrotic bone and acellular bone marrow (b+c)

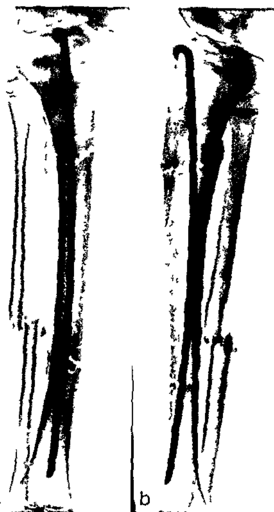


Figure 3 Radiograms 2 months after reimplantation Abundant periosteal bone formation throughout the total diaphyseal area

graphically (Figure 4) with a valgus deformity of the right tibia of 10° compared with the left

Microscopical investigation

When the Rush pin was removed a block of bone (Figure 4) was removed from the anteromedial cortex of the formerly extruded piece of diaphysis One month before this biopsy 250 mg Terramycin® × 4 was given *per os* Immediately before the biopsy 250 mg Terramycin® was given intravenously

The specimen of cortical bone was sawn transversely into small pieces Some of these were fixed in Bouin s solution and decalcified in formic acid (40 per cent) and sodium formiate (7 per cent) Transverse and longitudinal sections of this material were made with a thickness of about 12 mμ These sections were stained in Ehrlich s haematoxylin eosin Azan and Schmorl s picrothionin staining

The other small pieces of cortical bone were fixed in absolute ethyl alcohol and transverse sections were cut with a rotating saw the thickness of the sections was about 100 mμ The sections were examined in incident and transmitted light in a fluorescence microscope (Leitz Orthoplan)

The thickness of the antero medial cortex measured about 5–8 mm In undecalcified and unstained sections there was a brown colour in the vascular channels of the periosteal areas This colour was absent in the endosteal areas

In the cortical bone there was an irregular mesh work of necrotic and vital vascular channels and lamellar bone (Figures 5 and 6)

Both in the light microscopy and fluorescence microscopy there was no periosteal appositional bone formation The bone tissue immediately beneath the periosteum was partly necrotic and partly vital and newly formed the latter as



Figure 4 Radiograms 1 year after reimplantation The Rush pin has been removed and a biopsy has left a cortical defect Both fractures of the tibial shaft have healed The abundant bone formation laterally is due to the valgus deformity

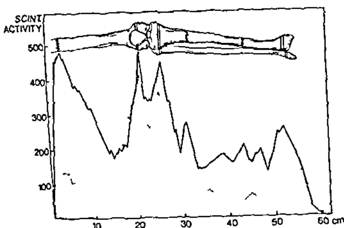


Figure 8 Profile diagram of fractured (———) and normal (- - - - -) tibia 2 months after reimplantation Note the high activities of the growth zones Generally higher activity in the fractured tibia despite necrotic diaphysis The localized activity over femur corresponds to the fracture

Table 1 Mean scintimetry values and indices of areas A–C of the fractured tibia and corresponding values of the normal tibia (within brackets)

	Area A		Area B		Area C		Ref index
	Mean act	Index	Mean act	Index	Mean act	Index	
2 weeks postop	247 4	380 6	121 8	187 3	102 9	158.3	0 65
2 months postop	144 6 (99 1)	267 9 (183 5)	58 1 (30 5)	111 3 (56 2)	46 1 (22 7)	85 4 (42 1)	0 54
9 months postop	–	–	59 0 (27 6)	105 4 (49 5)	–		0 56

sociated with invaginated vascular channels Osteoclastic activity was found in both vital and necrotic bone tissue

In the middle region of the cortex there was an increase in necrotic bone but vital bone was here also found in association with vascular channels In some regions there was osteoclastic activity of necrotic bone while in other regions there was more appositional bone formation Most of the vascular channels were made up of rdinary fibrous tissue with many blood vessels In some of the channels there was necrotic fibrous tissue without signs of osteoblasts and steoclasts

The endosteal region showed a 2–4 mm deep z ne of mainly necrotic tissue The osteocyte lacunes were empty Osteoblasts and osteoclasts as well as osteoid were absent. Most of the vascular channels consisted of an almost acellular fibrous and cystic tissue Most of the endosteal surface was necrotic The marrow cavity was filled with an almost acellular fibrillar tissue but in some areas there were signs of fibroblasts fat cells and phagocytosis There was no sign of infection Some of the veins were occluded by old thromboses without signs of revascularization

In conclusion the microscopic investigation showed pronounced osteoblastic and osteoclastic activity in the superficial part of the cortex originating from the periosteum and the vascular channels invading the necrotic cortical bone The lack of actual periosteal bone formation was probably the result of the fact that the biopsy was taken from the antero medial aspect of the tibia where [illegible]

weight bearing the endosteal regions of the cor

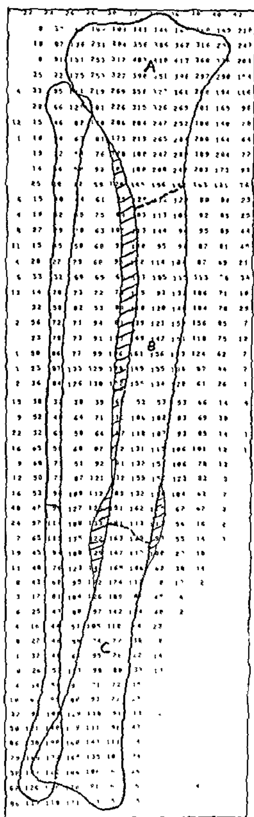


Figure 7 a Scintimetry of fractured tibia 2 weeks after reimplantation Note epiphyseal activities, high activities around the fractures and a pronounced diaphyseal activity corresponding to periosteal bone formation The bone mass here is dead (B). Shadowed area = abundant callus formation later seen on radiogram… (Figure 3)

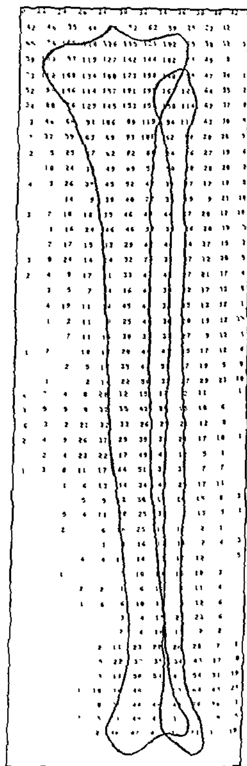


Figure 7 b Scintimetry of left intact tibia Note epiphyseal activities and the difference in comparison with the fractured tibial diaphysis

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FRACTURES OF THE NECK OF THE TALUS

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One hundred and twenty three patients with fracture of the neck of the talus were followed up over an average of 22 months Fifty four fractures were undisplaced, 53 associated with subtalar dislocation, and 16 associated with dislocation of the talus in both ankle joint and subtalar joint. Of the total 123 patients, 21 per cent (26/123) developed avascular necrosis, 31 per cent (38/123) developed talo crural and 47 per cent (58/123) subtalar osteoarthrosis Fifteen per cent (18/123) of the fractures united with considerable deformity and four per cent (5/123) exhibited non union of the neck Out of 63 patients with isolated fracture of the neck of the talus, 65 per cent (41/63) reported moderate or severe complaints, and 52 per cent (33/63) complained of functional disability often resulting in a change to lighter work Even among the 54 undisplaced cases there were unexpected numbers of late sequelae, such as osteoarthrosis, subjective complaints and disablement

Key words fracture of the neck of talus, avascular necrosis osteoarthrosis, prognosis

Accepted 19 x 76

Fracture of the talus is relatively rare This may be due to the rather deep location of the bone, the absence of tendon and muscle attachment, and the strength of the bone A consequence of this is that most reports on this type of fracture have been based on relatively few cases (Table 1)

The most common type of talar fracture is that of the neck which makes up about 50 per cent of all major talar injuries (Coltart 1952, Pennal 1963, Hawkins 1970 Kenwright & Taylor 1970) This type of fracture often entails secondary complications, especially subtalar and talo-crural osteoarthrosis and necrosis of the body, and its prognosis has generally been considered serious (Symes 1848, Sicaly 1909, McKeever 1963 Ken [illegible]

[illegible] This particularly applies to the assessment of the prognosis in relation to the various morphological types of this fracture, and also to the prognostic aspects relevant to the occurrence of osteonecrosis and osteoarthrosis

It is the object of this paper to evaluate a relatively large number of cases of fractures of the neck of the talus, with a sufficiently long follow-up, to allow an assessment of the prognosis and the complication rates relation to the different types of fracture

tical bone consisted of necrotic bone tissue and were only replaced to a small extent by new bone

Scintimetric investigation

Radionuclide scintimetry was done with ^{87m}Sr at 2 weeks (Figure 7) and 2 months (Figure 8) and with ^{85}Sr at 9 months after the accident Scintimetry was performed in two ways (1) with the detector, equipped with a focusing collimator stepwise scanning the entire tibia and fibula in the frontal plane (Figure 7 a and b) and (2) with the uncollimated detector moving at a constant height and speed from the groin along the centre of the bone to the foot so that a profile diagram was obtained (Figure 8)

The scintimetries were used for topologic and quantitative definition of the reparative process

The fractures divided the tibia into three areas (Figure 7 a) the proximal (A), the diaphyseal (B) and the distal area (C) After correction for background and soft tissue radiation, the mean values of each area were calculated For standardization with relation to individual retention and decay, these values were related to a reference index obtained from the normal tibia. Values thus obtained were called activity indexes of areas A–C

The scintimetry values here are directly related to the accretion rate of the bone tissue (Bauer 1968) The four maxima observed over the tibia correspond to the growth zones and the two fractures (Figures 7 a and 8)

In the growth zones the values were 2 3 fold increased probably reflecting the hyperaemia and overgrowth of a fractured bone

The high values observed around the fractures also reflected the reparative process The increased values over the reimplanted bone were more surprising However even though the bone was dead the periosteal reaction was 2 3 times that of the periosteum and bone on the normal side

DISCUSSION

There are two reasons why an expelled tibial diaphysis should be reimplanted Firstly, it provides an automatically adequate spacer which preserves the shape and length of the bone during the rebuilding process Secondly, it is an immunologically compatible substance which acts as a meshwork for the osteoblastic activity, and is capable of being removed gradually so that the physical strength of the bone is preserved The remarkably swift and uneventful healing process observed in our case can be attributed to the youth of the patient the absence of infection, and, most important of all, the preservation of the periosteum and its blood supply

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Pantazopoulos et al 1974) the 123 fractures of the neck of the talus were radiologically divided into three groups

Group 1 comprised undisplaced fractures through the neck of the talus not involving the ankle joint or subtalar joint (Figure 1)

Group 2 comprised displaced fractures through the neck of the talus with subluxation or dislocation of the subtalar joint but with the trochlea in position in the ankle joint (Figure 2)

Group 3 comprised displaced fractures through the neck of the talus with dislocation of the ankle joint as well as the subtalar joint (Figure 3)

The 123 patients were divided into the three groups as follows 54 (44 per cent) in group 1 53 (43 per cent) in group 2 and 16 (13 per cent) in group 3 All 16 patients of group 3 had posterior dislocation of the trochlea

Simultaneous injuries of the other tarsal and metatarsal bones and of the malleoli are common as well as fractures of other limbs Sixty patients had other injuries besides fracture of the talus 35 of these had malleolar fracture and 13 calcanear fracture Thus the fracture of the neck of the talus was an isolated injury in only 63 patients (51 per cent)

Table 3 Incidence of avascular necrosis

Morphol group	Fracture of neck of talus No	Avascular necrosis No
Group 1	54 (100%)	2 (4%)
Group 2	53 (100%)	13 (24%)
Group 3	16 (100%)	11 (69%)
Total	12 (100%)	26 (21%)

Init of treatment

All patients of group 1 received conservative treatment seven were treated with weight release for 6 to 8 weeks while the remaining 47 had a plaster cast with no weight bearing for 6 to 14 weeks All group 1 fractures united.

Of the 53 patients in group 2 four were treated by open reduction 30 by closed reduction followed by plaster cast and no weight bearing The remaining 19 patients were treated by plaster cast without reduction The period of plaster fixation and weight release averaged 8 to 12 weeks Seven of the 53 fractures were open

In group 3 11 of the 16 patients were treated by open reduction one by primary excision of the trochlea one by primary subtalar arthrodesis and three by closed reduction Six of the fractures in this group were open

RESULTS

The long term prognosis is mainly determined by the occurrence of necrosis of the body of the talus, osteoarthrosis, and union with deformity or non union

Osteonecrosis The avascular necrosis of the body of the talus was graded into four groups

In grade 1 there was a condensation of the bone but no deformity in grade 2 there was a healed condensed corpus with mild to moderate deformity, in grade 3 there was a healed condensed corpus with severe deformity, and in grade 4 there was sequestration of the trochlea i e no healing

Twenty six of the 123 patients (21 per cent) developed avascular necrosis of the trochlea (Table 3) Seven were of grade 1 16 of grade 2, two of grade 3 and one of grade 4 It was surprising to find two

Table 4 Occurrence of osteoarthrosis mal union and non union

Morphol group	Fracture of neck No	Talo-crural osteoarthrosis No	Subtalar osteoarthrosis No	Mal union No	Non union No
Group 1	54 (100%)	8 (15%)	13 (24%)	0 (0%)	0 (0%)
Group 2	53 (100%)	19 (36%)	35 (66%)	15 (28%)	3 (6%)
Group 3	16 (100%)	11 (69%)	10 (63%)	3 (18%)	2 (12%)
Total	123 (100%)	38 (31%)	58 (47%)	18 (15%)	5 (4%)

Table 1 Incidence of avascular necrosis in fractures of the neck of the talus in previous series

	Fracture of neck of talus No	Avascular necrosis No
McKeever 1943	17	12 (71%)
Coltart 1952	106 *	26 (25%)
Sullivan & Jackson 1958	29 **	7 (24%)
Hawkins 1970	52	30 (58%)
Pantazopoulos et al 1974	20	9 (45%)
Lorentzen et al 1976	123	26 (21%)

* Nearly all due to flying accidents during the Second World War

** Fourteen of the patients were children under 16 years Material not consecutive

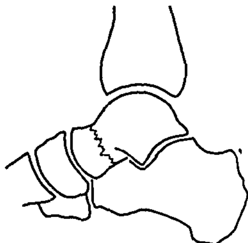


Figure 1 Group 1 fractures Undisplaced fracture through the neck of the talus Ankle joint and subtalar joint not involved

PATIENTS AND METHODS

The material for the study has been obtained from the Danish Health Insurance Authority which received, during the period 1945–1972, reports on 218 patients with injuries to the talus, including 123 with fractures through the neck

For all 123 patients a final specialist report was available, comprising a clinical and a radiological evaluation These specialist reports together with the case records and X ray films formed the basis of the present study

The follow-up period, from the time of accident to the final examination, ranged from 7 to 73 months mean 22 months

The patient material is representative except for a male predominance, as housewives are generally not insured Out of the 123 patients, 107 were males and 16 females The age range was between 9 and 70 years, mean 39 years Table 2 gives the causes of the injuries

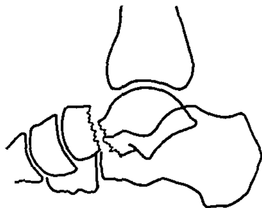


Figure 2 Group 2 fractures Displaced fracture through the neck of the talus The subtalar joint is subluxated or completely dislocated Trochlea in position in the ankle joint

Table 2 Cause of injury

	Fracture of neck of talus No
Fall	47 (39%)
Direct trauma to the foot	34 (28%)
Distortion	10 (8%)
Traffic accident	31 (25%)
Total	123 (100%)

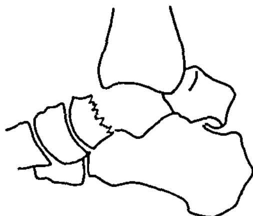


Figure 3 Group 3 fractures Displaced fracture through the neck of the talus Talar body dislocated in both ankle and subtalar joint

Classification

In accordance with the conventional classification (Coltart 1952, Watson-Jones 1962 Pennal 1963, Hawkins 1970, Kenwright & Taylor 1970

Five patients exhibited non union of the neck One also had avascular necrosis of the body All ended up with severe complaints

Subjective and objective results In order to assess the prognosis of fractures of the neck of the talus as regards sub jective complaints and rehabilitation, we analyzed the 63 patients in whom the talar fracture was an isolated injury

Table 5 presents the subjective re sults It is striking that so many patients with undisplaced fractures had moderate or severe complaints (46 per cent) How ever this is in accordance with the large frequency of osteoarthrosis in these pa tients

Rehabilitation is shown in Table 6 It should be noted that among the patients with undisplaced fractures 10 (38 per cent) were unable to continue in their former occupation We have also in cluded the degree of disablement as sessed by the Health Insurance Author ities (Table 7)

DISCUSSION

So far the prognosis of undisplaced frac ture of the neck of the talus (group 1) has been considered favourable (Coltart 1952 Hawkins 1970 Pantazopoulos et al 1974) However the 54 undisplaced frac tures (group 1) in the present material were associated with a considerable in cidence of complications comprising two cases of avascular necrosis eight of talo crural osteoarthrosis and 13 of subtalar osteoarthrosis Forty six per cent had moderate or severe complaints and only 62 per cent could continue in their pre vious work

It is well known that the prognosis of displaced fractures of the neck (groups 2 and 3) is poor but this has been at tributed to the occurrence of avascular necrosis Our material shows that even those patients with displaced fractures of the neck who avoid necrosis of the body run a considerable risk of developing osteoarthrosis—especially in the subtalar joint Of the 45 patients without necrosis of the body, 21 (47 per cent) developed subtalar osteoarthrosis

It is interesting to find a high incidence of talo crural osteoarthrosis in groups 1 and 2 in which the fracture does not in-volve the ankle joint It is evident that talo-crural osteoarthrosis may occur when the body is necrotic When sub-tracting the cases with osteonecrosis, we find the same percentage of cases with talo-crural osteoarthrosis (13 per cent) in the three morphological groups, in-dicating that regardless of which type of fracture of the neck it causes, the trauma exerts violent force upon the ankle joint in which it gives rise to cartilaginous and ligamentous damage This assumption is supported by the finding that 35 (28 per cent) of the fractures of the neck of the talus were associated with malleolar fractures

In the literature, the incidence of avascular necrosis following fracture of the neck of the talus has been reported to be from 24 to 71 per cent (Table 1) The high incidence has been reported par-ticularly by authors using small numbers of patients However, these studies have been predominated by rather severe frac-tures of the neck and included only a few undisplaced group 1 fractures in which necrosis is rare

In our material group 1 fractures made up 44 per cent, and the incidence of avascular necrosis proved to be 21 per cent This agrees with the only large series reported so far (Coltart 1952)

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Table 5. Subjective complaints in 63 patients with isolated fracture of the neck of the talus

Morphol. group	Fracture of neck of talus No.	No complaints No.	Moderate complaints No.	Severe complaints No.
Group 1	26 (100%)	14 (54%)	10 (38%)	2 (8%)
Group 2	31 (100%)	7 (23%)	11 (35%)	13 (4[illegible]%)
Group 3	6 (100%)	1 (17%)	3 (50%)	2 (33%)
Total	63 (100%)	22 (35%)	24 (38%)	17 ([illegible]%)

Moderate complaints: Light to moderate painful gait, walking ability normal or slightly impaired.
Severe complaints: Severely painful gait with severely impaired walking ability.

Table 6. Rehabilitation in 63 patients with isolated fracture of the neck of the talus

Morphol. group	Fracture of neck of talus No.	Same work No.	Lighter work No.	Not working No.
Group 1	26 (100%)	16 (62%)	8 (30%)	2 (8%)
Group 2	31 (100%)	14 (45%)	14 (45%)	3 (10%)
Group 3	6 (100%)	0 (0%)	5 (83%)	1 (1[illegible]%)
Total	63 (100%)	30 (48%)	27 (43%)	6 (9[illegible])

Table 7. Degree of disablement in 63 patients with isolated fracture of the neck of the talus

Morphol. group	Fracture of neck of talus No.	0% No.	5–8% No.	10–18% No.	20–50% No.
Group 1	26	5	11	8	2
Group 2	31	1	5	16	9
Group 3	6	0	1	3	2
Total	63	6	17	27	13

cases of osteonecrosis in the group of undisplaced fractures, both were grade 2.

Osteoarthrosis. About one third of the 123 patients developed talo-crural osteoarthrosis, whereas one half developed subtalar osteoarthrosis (Table 4). Twenty-nine patients (24 per cent) had talo-crural as well as subtalar osteoarthrosis. The incidence of talo-crural osteoarthrosis evenly increased in groups 1 and 3, whereas subtalar osteoarthrosis was almost unchanged in groups 2 and 3 (Table 4).

All patients with avascular necrosis developed osteoarthrosis. Of the seven patients with grade 1 necrosis, six developed osteoarthrosis of the talo-crural as well as subtalar joint. All 19 patients with grade 2–4 necrosis developed severe talo-crural and subtalar osteoarthrosis.

Deformity and non-union. Eighteen fractures, all from groups 2 and 3, united with appreciable deformity of the neck (Table 4). A poor subjective result of moderate or severe complaints was obtained from 17 of these 18 patients.

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POST-TRAUMATIC SINUS TARSI SYNDROME

An Anatomical and Radiological Study

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Four cases of sinus tarsi syndrome are presented They were studied by means of arthrography of the posterior subtalar joint and histological examination of sinus tarsi soft tissue The obliteration of synovial recesses on posterior subtalar joint arthrography can be explained by synovial hyperplasia and by cicatricial remodelling of ligament tissue

Key words subtalar joint arthrography tarsal sinus syndrome diagnosis

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The X ray pictures of patients with sinus tarsi syndrome do not show skeletal changes (Debrunner 1963 Hauser 1962 Navarre 1966) Meyer & Taillard (1974) have previously described arthrographic changes in the posterior subtalar joint in nine patients suffering from post traumatic pain in the midtarsal joints These changes were considered significant since they were not observed in 90 clinically normal subjects Two of the patients had pain over the lateral part of the sinus tarsi thus presenting a clinical picture similar to that described by O Connor in 1956 as "sinus tarsi syndrome Therefore a clinical and radiological entity of post traumatic sinus tarsi syndrome was proposed by Meyer & Taillard (1974) on the basis of this association between foot pain (not necessarily confined to the sinus tarsi) and a characteristic arthrographic appearance of the posterior subtalar joint viz absence of synovial recesses in front of the interosseous ligament

The present article describes four cases of this syndrome which were studied anatomically and radiologically

Normal Anatomy and Radiological Appearance of the Sinus Tarsi

Anatomy The cohesion of the talus and the calcaneus is ensured by several ligaments primarily the interosseous talocalcaneal ligament The latter is attached to the sulcus tali and the sulcus calcanei which form the roof and floor of the sinus tarsi The ligament is thinner and more fibrous on the medial side and thicker on the lateral side where its bundles intermingle with fatty tissue (Figure 1) This transversal sheet in the sinus tarsi thus separates the two diarthrodial joints which are found between the talus and the calcaneus The anterior joint forms part of the talo calcaneo-navicular joint and the posterior one is the actual talocalcaneal or subtalar joint

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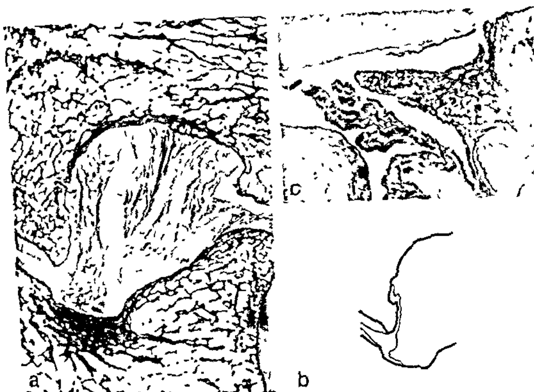


Figure 2 Histology of a normal sinus tarsi (same case as Figure 1)

a) Topographical histology (lateral sagittal section—Haematoxylin eosin × 2 7) Bundles of interosseous ligament separated by adipose tissue Synovial membrane layer on the anterior and posterior surfaces of the ligament with synovial recesses on the latter

b) Diagram of the posterior part Thick line, bony contour, thin line, cartilaginous and synovial surfaces

c) Hyperplastic synovial fringe on the posterior surface of the interosseous ligament (sagittal section more medial than in (a)—Haematoxylin eosin × 22) On the right, adipose tissue of the ligament On the left cartilaginous talar and calcaneal surfaces

sinus tarsi was found to contain scar tissue in case 1 and the lateral talocalcaneal ligament [illegible] fibrous capsule with bundles of lateral talocalcaneal ligament, the synovial membrane and adjacent connective and adipose tissue In addition the biopsy material of case 3 included talar and calcaneal osteocartilaginous surfaces

Case 4 showed slight signs of cicatricial remodelling in the very small fragment of ligament studied The changes seen in the other three cases were decidedly abnormal and were particularly marked in case 1

The synovial membrane exhibited *papillary* hyperplasia (Figure 5) characterized by an abundance of cells in some places and *fibrous* changes in others a lack of fibrin deposits, *absence of polymorphonuclear or lymphoplasmocytic infiltration* except for a few small clusters of lymphocytes (Figure 6 a), haemosiderin *deposits* indicative of old haemorrhages (clear deposits in case 1, faint ones in case 3 and none at all in case 2), and thickening of the adjacent blood vessels In case 1 some remnants of pre existing *ligaments* were embedded in hyperplastic synovial membrane (Figure 6 b)

Cicatricial remodelling in the ligament was discrete [illegible] an [illegible] ex [illegible] formed scar tissue—Figure 7)

In case 3 the cartilage surfaces showed a mar-

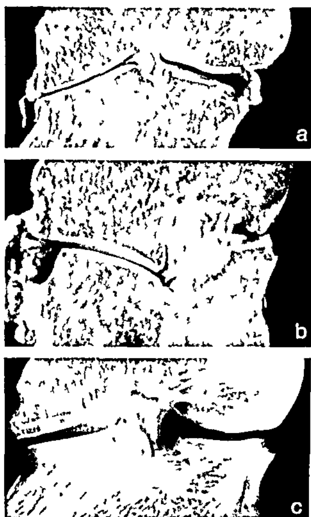


Figure 1 Normal subtalar joint with interosseous ligament (72 year old man with no joint disease) Anterior region is on the right

a) Macroscopic appearance of a medial sagittal surface

b) Macroscopic appearance of a lateral sagittal surface

c) X ray of a central sagittal section (1 cm thick)

Hence, both sides of the interosseous talocalcaneal ligament are lined with synovial membrane This was observed histologically on sagittal sections of two anatomical specimens taken from subjects with no osteoarticular pathology On the posterior side the synovium formed small superior and inferior recesses and occasional papillary folds due to simple hyperplasia of the lining cells (Figure 2) On the anterior side fairly similar small recesses were observed on certain sections The synovial membrane lined the remainder of the articular cavity of the posterior subtalar joint, particularly at the level of the well developed posterior, lateral, and medial recesses

Radiological appearance The soft tissues of the sinus tarsi can be evaluated radiologically only by means of an arthrographic mould However, arthrography of the talocalcaneo-navicular joint involves technical problems and does not readily permit a study of the sinus tarsi Arthrography of the posterior subtalar joint was therefore performed as proposed by Meyer (Meyer 1973 Meyer & Taillard 1974), the best view being obtained with an image intensifier The contrast medium injected into the postero lateral part of the joint cavity formed a thin layer between the calcaneal and talar cartilage surfaces and filled the medial and lateral recesses It then penetrated into the posterior joint cavity, which on oblique view arthrography, resulted in an opacification of half the surface of the sinus tarsi (Figure 3) By filling small synovial recesses or folds on the posterior side of the interosseous talocalcaneal ligament the contrast medium produced indented images that were clearly visible on transversal arthrographic *post mortem* sections (Meyer 1973) as well as on lateral view arthrography (Figure 3) Communication with the talocalcaneo-navicular joint was rare

CASE REPORTS

The clinical details of the four cases studied are given in Table 1 All cases showed the two subtalar arthrographic changes (Figure 4) formerly considered to be characteristic of pathological alteration of the soft tissues of the sinus tarsi (Meyer & Taillard 1974) viz absence of filling of the sinus tarsi and of several small recesses in the lining of the interosseous ligament

After the failure of medical treatment surgery was performed (Table 1) leading to favourable results in all four cases During operation the

Table 1 Clinical details of the four cases studied

	Case 1	Case 2	Case 3	Case 4
Sex	male	male	male	male
Age (at biopsy)	25 years	24 years	30 years	47 years
Nature of injury	sprain (left foot) tear of calcaneo fibular ligament	sprain (right foot)	fracture of fibula and malleolus—fissure of calcaneus (left foot)	fracture of os trigonum tear of talo calcaneal ligament
Interval between injury and arthrography	?	2 years 5 months	1 year 10 months	1 year 6 months
Interval between injury and surgery	?	3 years	1 year 11 months	2 years
Intervening symptoms	pain	pain (particularly upon palpation of sinus tarsi)	pain	pain (particularly upon palpation of sinus tarsi)
Nature of operation	plasty of calcaneo fibular ligament sinus tarsi curettage	subtalar arthrodesis sinus tarsi curettage	subtalar arthrodesis sinus tarsi curettage	sinus tarsi curettage
Biopsy	sinus tarsi contents fibrous capsule with ligament synovial membrane	sinus tarsi contents fibrous capsule with ligament synovial membrane	sinus tarsi contents fibrous capsule with ligament synovial membrane + bone and cartilage	sinus tarsi contents fibrous capsule with ligament synovial membrane
Biopsy number	T 3883/74	T 11432/74	T 10372/73	T 2001/74



Figure 3 Normal arthrography of a posterior subtalar joint (30-year-old man with no joint disease) Oblique lateral view Opacification of half the surface of the sinus tarsi with moulding of small synovial recesses

ginal osteophyte indicating a minor equivalent of osteoarthritic remodelling, the underlying bone showed evidence of discrete non-specific remodelling

DISCUSSION

Studies of the normal histological appearance of the sinus tarsi make it clear why arthrography is valuable in the diagnosis of soft tissue changes (Figure 2). They enable one to appreciate why remodelling with synovial hyperplasia has to be marked before it can obliterate the radiological images of synovial recesses or fringes As a result of such studies it can further be understood why such obliteration might also be caused by joint effusion, particularly haemorrhage

Microscopical observations strongly suggest that trauma can cause remodelling of this kind in the soft tissues of the sinus tarsi In the cases presented here the changes were quantitatively rather marked and qualitatively similar to those usually seen in post-traumatic conditions (as opposed to the changes seen in infections or rheumatoid illness) Of the analogous histological examinations mentioned in the literature, "inflammatory" changes were observed in some of them (Blasnik cited by Komprda 1966) but not in others (O'Connor cited in Brown 1960 and Komprda 1966) In the light of our experience, this discrepancy might be due to differences in the quantity and orientation of the material examined In our opinion, arthrography is not diag





Figure 4 Arthrography of the posterior subtalar joint with pathological changes in the sinus tarsi —oblique lateral view (a) Case 1 (b) Case 2 Partial obliteration of the posterior subtalar joint Contrast medium is forced to the back Small synovial recesses are not visible The lateral and posterior synovial recesses are different in appearance in both cases

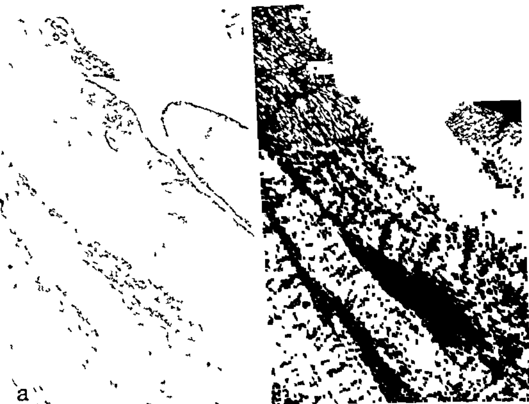


Figure 7 Case 1 Ligament bundles connected to fibrous tissue resulting from cicatricial remodelling

a) Normal light

b) Polarized light showing differences in structure between pre existing ligament bundles (lower left) and fibrous scar tissue (upper right)—(Haematoxylin eosin × 22)

nostically useful immediately after trauma because it is only later on that synovial hyperplas[illegible]

and cartilage changes observed in case 4 are not visible on X rays but may be considered as early osteoarthritic changes similar to those sometimes seen in the subtalar joint (Brown 1960, Debrunner 1963 Komprda 1966)

These pathological soft tissue changes in the sinus tarsi seem to be secondary mainly to rupture of the calcaneofibular ligament This was observed clinically in nine cases in a previous study (Meyer & Taillard 1974) In our present case 1, the rupture was observed at operation and was unassociated with any bone changes Simple plasty of the ligament resulted in the disappearance of symptoms, which were still absent after 6 months This is consistent with Castaing s view on the role of the calcaneofibular ligament in subtalar stability (Castaing 1970)

An anatomical and radiological picture of the post traumatic sinus tarsi syndrome is thus recognizable However, it cannot be superimposed on a characteristic clinical picture For example, in case 1, which was radiologically and histologically typical, there was rather diffuse pain in the mediotarsal region and no elective pain over the sinus tarsi Conversely, a post traumatic syndrome featuring just such pain has been observed



Figure 5 Case 1 Synovial hyperplasia without inflammatory cells
a) Overall topographical view with underlying adipose tissue (Haematoxylin eosin × 2?)
b) Detail (Haematoxylin eosin × ?5)

Figure 6 Case 1 a) Synovial fringe Hyperplasia of the lining cells with a small cluster of lymphocytes (Haematoxylin eosin × 180)
b) Synovial fringe Lower left fibroblastic hyperplasia Above right fibrous scar tissue which includes some remnants of ligament this reflects the destruction of pre-existing tissue (Van Gieson × 180)

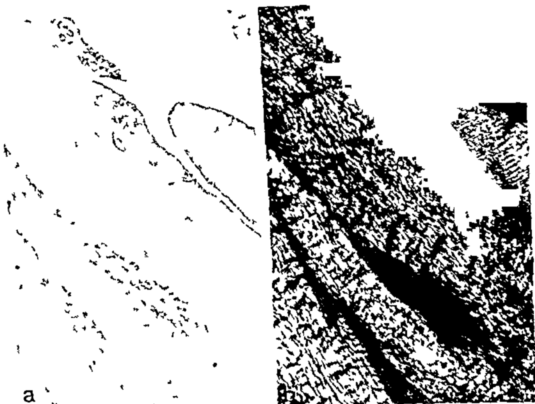


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a) Normal light
b) Polarized light showing differences in structure between pre existing ligament bundles (lower left) and fibrous scar tissue (upper right)—(Haematoxylin eosin × 22)

nostically useful immediately after trauma because it is only later that synovial hyperplasia develops moreover misleading appearances can be produced by joint effusion The rather discrete bone and cartilage changes observed in case 4 are not visible on X rays but may be considered as early osteoarthritic changes similar to those sometimes seen in the subtalar joint (Brown 1960 Debrunner 1963 Komprda 1966)

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in the absence of arthrographic changes (Meyer & Taillard 1974)

ACKNOWLEDGEMENT

The authors express their thanks to Dr F Indermuhle (Porrentruy Hospital) for having kindly provided them with the clinical and radiological data for case 4

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POSTOPERATIVE SYNOVIAL FLUID

Metabolic Response to Meniscectomy or Synovectomy

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The metabolic response of synovial tissue to surgery was investigated by synovial fluid analysis after two types of operations medial meniscectomy and synovectomy Analyses of intra articular fluid were also performed in non-operated patients with traumatic effusion or chronic synovitis in the knee It was found that the knee joint metabolism in chronic synovitis is shifted towards anaerobic glycolysis in both operated and non operated patients whereas meniscectomized and traumatized knees are more capable of maintaining oxidative metabolism The data also demonstrate that one of the main reasons for decreased oxygen supply on the articular surface after meniscec tomies or synovectomies is excessive intra articular effusion which, according to earlier investigations produces pressure in the joint cavity and inhibits local capillary circulation

Key words synovial fluid analysis synovial tissue metabolism synovial gas tensions meniscectomy synovectomy joint trauma chronic synovitis tissue repair

Accepted 21 i 77

The useful information obtained from analysis of the synovial fluid has ren dered this procedure an important factor in the diagnosis of joint disease Under normal conditions the synovial tissue is highly vascular and it serves as a di alyzing membrane between the joint cavity and the circulation Plasma di alysate flows into the joint cavity and serves to lubricate as well as to supply oxygen and other nutrients to the joint cartilage (cf Yehia & Duncan 1975)

Recent investigations have demon strated that synovial fluid oxygen tension decreases to low levels in the knees of arthritis patients (Falchuk et al 1970 Lund-Olesen 1970 Treuhaft & McCarty 1971 Goetzl et al 1974 a, b) In general, the lowest oxygen tensions have been found in inflammatory joint disease, fol lowed in turn by degenerative and trau matic joint disease These observations suggest the possibility that prolonged synovial fluid hypoxia might cause chon drocyte damage and death at the artic- ular surface

The low synovial fluid PO_2 in arthritic joints signifies a changeover of local tissue from predominantly aerobic to a largely anaerobic, glycolytic metabolism (McCarty 1974) Ropes & Bauer (1953) observed an inverse relationship between synovial fluid glucose and lactate levels Glucose diffuses into cells and is phos-

in the absence of arthrographic changes (Meyer & Taillard 1974)

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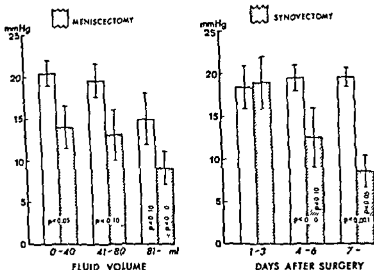


Figure 2 Oxygen tensions of postoperative synovial fluids from knees of patients after medial meniscectomy or synovectomy In the first volume group the difference in PO_2 levels between meniscectomies and synovectomies was statistically significant ($P < 0.05$) In synovectomized patients $P < 0.05$ for the decline of PO_2 between the first and the third time group In the third time group $P < 0.001$ for the difference of PO_2 between meniscectomies and synovectomies, $P < 0.10$ denotes almost significant

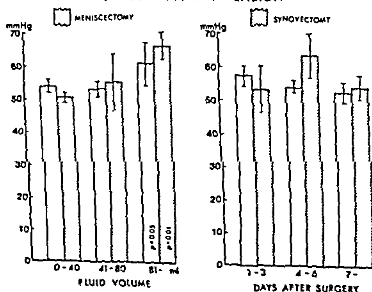


Figure 3 Carbon dioxide tensions of postoperative synovial fluids from knees of patients after medial meniscectomy or synovectomy The statistically significant results are indicated as P-values (t test) in the corresponding columns

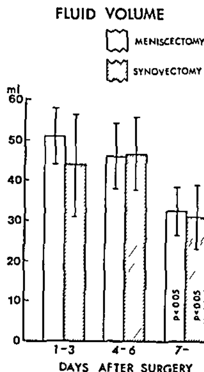


Figure 1 Volumes of postoperative synovial fluids from knees of patients after medial meniscectomy or synovectomy Each column indicates the mean ± the standard error of the mean The decreases in fluid volumes between the first and the third time groups were statistically significant ($P < 0.05$ both for meniscectomies and synovectomies, t test)

phorylated which prevents it from diffusing out again until it is metabolized to pyruvate which in turn is converted to lactate

Little is known about the metabolic response of synovial tissue to surgical trauma In the present work this topic was investigated by means of postoperative synovial fluid analysis after two different types of operations, medial meniscectomy and synovectomy For comparison, synovial fluid analyses were also performed in non operated hospitalized orthopedic patients with traumatic effusion or chronic synovitis in the knee joint

PATIENTS AND METHODS

Postoperative synovial fluid analyses were carried out consecutively after 27 medial meniscectomies and 10 synovectomies

The mean age of the meniscectomy patients was 39 years Eighteen cases were caused by traumatic distorsion and the preoperative period from the time of injury to the operation varied from 3 to 8 months In nine patients the rupture was due to degeneration of the semilunar cartilage The meniscectomies were carried out through a medial curvilinear or transverse incision and no postoperative tube drainage was employed Mobilization of the knee was started on the first postoperative day, and weightbearing was initiated 10 to 14 days after surgery

Indications for total synovectomy were rheumatoid arthritis (four patients) degenerative joint disease (three patients) and post operative arthritis (three patients) The mean age of this group was 36 years The synovectomies were performed through two separate parapatellar incisions medial and lateral followed by 2 days postoperative tube drainage Mobilization of the knees was started on the first postoperative day and weightbearing was initiated 10 to 14 days after surgery

Additionally, synovial fluid analyses were performed in five patients with traumatic effusion in the knee joint after a fresh injury (three intra articular fractures and two distorsions) and in nine non operated patients with chronic synovitis (six patients with rheumatoid arthritis two patients with a degenerative joint disease and one postoperative arthritis)

The knees of the operated patients were inspected daily and if marked fluctuation was noted all accumulated fluid was aspirated with a sterile hypodermic needle into a heparinized glass syringe The dead space of the syringe was filled with anoxic saline solution to prevent air bubbles from entering the sample The volumes of the aspirated fluids were measured and the samples were placed on crushed ice and carried to the laboratory for the assay of PO_2 PCO_2 and pH determination Samples were injected into a thermostated cuvette containing either a Clark type oxygen electrode or a Severinghaus carbon dioxide electrode The electrodes were connected with a gas monitor type PHM 71 (Radiometer Copenhagen Denmark) Zero adjustment of the O_2 electrode was obtained with gaseous nitrogen and calibration was performed at 37° C using aerated saline solution with a PO_2 of 150 mmHg The PCO_2 electrode was calibrated against two moistened gas mixtures with CO_2 tensions of 20 and 60 mmHg respectively The pH of the fluid specimens was measured by means of a Radiometer pH meter attached to a Radiometer blood micro system type BMS 2 and the gas monitor

Glucose in the synovial fluid was measured enzymatically with glucose oxidase (C P Boehringer et Soehne GmbH Germany Biochemical

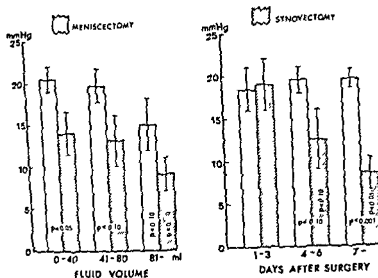


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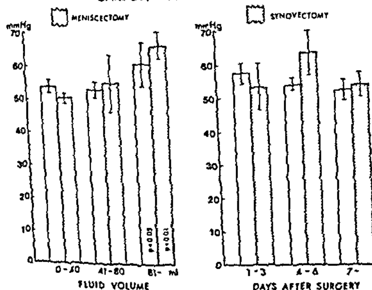


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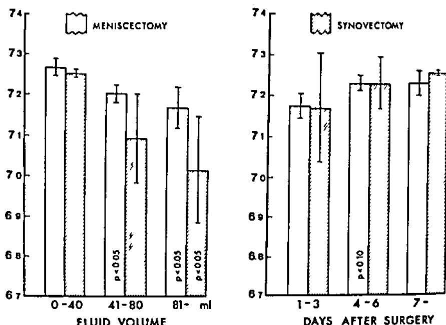


Figure 4 The pH of postoperative synovial fluids from knees of patients after medial meniscectomy or synovectomy

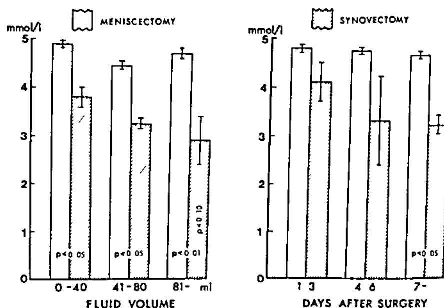


Figure 5 Glucose concentrations of postoperative synovial fluids from knees of patients after medial meniscectomy or synovectomy

Test Combination) For determinations of synovial fluid pyruvate and lactate a 1 0 ml aliquot of fluid was deproteinized by adding an equal volume of ice cold 1 0 M perchloric acid Pyruvate and lactate were determined by the standard ultraviolet methods (C F Boehringer et Soehne GmbH Biochemical Test Combination) using a Beckman DU spectrophotometer Hemoglobin was determined as cyanmethemoglobin as recommended by the European Society of Haematology

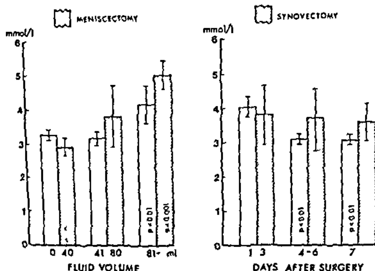


Figure 6 Lactate concentrations of postoperative synovial fluids from knees of patients after medial meniscectomy or synovectomy

(1965) Protein was assayed with the Folin phenol agent as described by Lowry et al (1951) Bacteriological examination of synovial fluid samples showed that all joints remained un infected throughout the study

The statistical significance of the results was calculated by means of Student's *t* test and linear regression analysis

RESULTS

During the postoperative period intraarticular accumulation of fluid declined gradually in both groups (Figure 1) Generally, the PO_2 levels after synovectomies were clearly lower than after meniscectomies (Figure 2) As healing progressed the PO_2 underwent a steep decline in the synovectomy group but remained unchanged after meniscectomies The PCO_2 values were relatively stable throughout the observation period (Figure 3) Both operated groups showed elevated carbon dioxide tensions in the largest fluid samples Overall, the mean pH increased slightly during the postoperative period and the lowest values were observed in the largest postsynovectomy fluid samples (Figure 4) Glucose concentrations of the intra articular fluid were significantly lower after synovectomies than after meniscectomies (Figure 5) The difference in glu cose levels between the groups was main tained throughout the observation period Increases in fluid volumes were generally associated with elevations of lactate and the lactate/pyruvate ratio in both operated groups (Figures 6 and 7) In meniscectomies these parameters declined markedly during the early postoperative period In both operated groups accumulations of CO_2 and lactate were associated with a linear decrease of pH (for meniscectomies, see Figure 8) In meniscectomized joints the mean hemoglobin concentration decreased noticeably in large fluid volumes but showed no essential changes during the course of healing After synovectomies intraarticular hemoglobin underwent a slow decrease as tissue repair progressed Changes in hemoglobin concentration

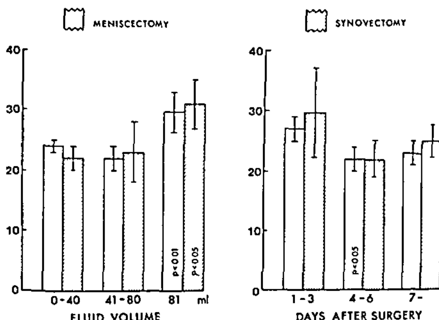


Figure 7 Lactate/pyruvate ratios of postoperative synovial fluids from knees of patients after medial meniscectomy or synovectomy

were reflected in corresponding changes in total protein in both operated groups (Figure 9)

In meniscectomized joints a high PO_2 level was associated with elevated levels of pH ($r = +0.65$**) and hemoglobin ($r = +0.36$*) and with decreased values of PCO_2 ($r = +0.74$**) and lactate ($r = -0.40$*) Synovial fluid PCO_2 was directly related to the concentration of lactate ($r = +0.50$**) and the lactate/pyruvate ratio ($r = +0.43$**) Inverse relationships were demonstrated between levels of lactate and pH ($r = -0.36$*), and PCO_2 and pH ($r = -0.75$**) Intra-articular hemoglobin concentration demonstrated a direct correlation with total protein ($r = 0.94$**)

In synovectomized joints a low PO_2 value was associated with a decreased glucose concentration ($r = +0.69$*) and lactate/pyruvate ratio ($r = -0.65$*) Both lactate concentration and lactate/pyruvate ratio were directly related to

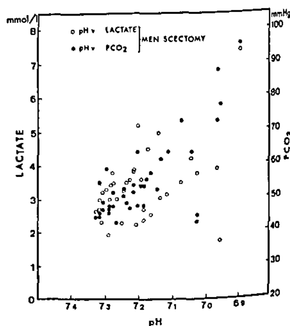


Figure 8 Relationship between postoperative synovial fluid PCO_2 or lactate and pH in knees of patients after medial meniscectomy

* In linear regression analysis confidence limit for the correlation coefficient r was greater than 95 per cent

** In linear regression analysis confidence limit for the correlation coefficient r was greater than 99 per cent

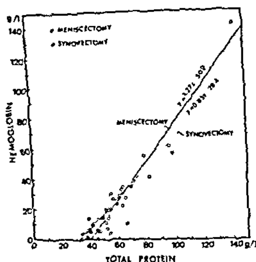


Figure 3 Relationship between hemoglobin and total protein concentrations in postoperative synovial fluids from knees of patients after meniscectomy or synovectomy Linear regression equations are indicated

carbon dioxide tension, with r = +0 84** and + 0 89**, respectively Inverse relationships were found between lactate and pH (r = —0 73*), and PCO_2 and pH (r = —0 79*) Hemoglobin concentration correlated significantly with total protein concentration (r = + 0 93**)

In non-operated patients traumatic intra articular effusions possessed markedly higher PO_2 levels, larger concentrations of hemoglobin as well as total protein and lower lactate/pyruvate ratios compared with synovial fluids from joints with chronic synovitis (Table 1) In non operated chronic synovitis joints, synovial fluid PCO_2 was inversely related to the levels of PO_2 (r = —0 66*) and pH (r = — 0 91*)

DISCUSSION

This report suggests that large intra articular accumulation of fluid reduces the availability of oxygen in the joint cavity (Figure 2) However, it is also possible that formation of fluid and tissue edema are enhanced by local hypoxia To test the relative importance of these two effects, the following experiment was performed All fluid accumulated in the joints of four meniscectomy patients and three synovectomy patients was aspirated, fluid volumes were measured, and the analyses mentioned earlier were made After 24 hours, aspirations and measurements were repeated The latter samples were 30 to 50 per cent of the original volumes, and the mean PO_2 levels were nearly twice the original values

Correspondingly, decrease in intra articular fluid volumes resulted in a decrease of both PCO_2 and the lactate/pyruvate ratio, whereas pH was elevated These data demonstrate conclusively that one of the main reasons for decreased oxygen supply at the articular surface after meniscectomies or synovectomies is excessive intra articular effusion On the other hand, the rate of accumulation of fluid is likely to depend on the extent of trauma produced during surgery

An additional factor decreasing the PO_2 levels, especially after synovectomy, could be increased oxygen utilization by the large surface of healing tissue This is supported by the fact that the intra-articular PO_2 declined after synovectomies as healing progressed but remained nearly unchanged in meniscectomized patients The overall high levels of intra articular PO_2 in both operated groups in the early postoperative phase were probably caused by capillary bleeding after a fresh trauma and also by diffusion of oxygen from the air during operation

Intra articular accumulation of fluid probably produces excessive pressure in the joint cavity and this may inhibit capillary circulation and the supply of oxygen as well as other nutrients, to the repair area Jayson & St John Dixon (1970) demonstrated that the intra articular pressure in the normal knee at

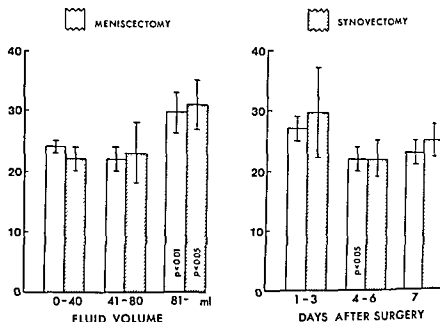


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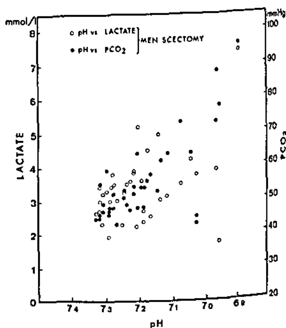


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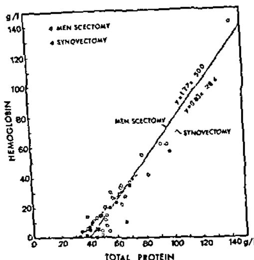


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DISCUSSION

This report suggests that large intra-articular accumulation of fluid reduces the availability of oxygen in the joint cavity (Figure 2) However, it is also possible that formation of fluid and tissue edema are enhanced by local hypoxia To test the relative importance of these two effects, the following experiment was performed All fluid accumulated in the joints of four meniscectomy patients and three *synovectomy patients* was aspirated, fluid volumes were measured, and the analyses mentioned earlier were made After 24 hours, aspirations and measurements were repeated The latter samples were *30 to 50 per cent of* the original volumes, and the mean PO_2 levels were nearly twice the original values

Correspondingly, decrease in intra-articular fluid volumes *resulted in a* decrease of both PCO_2 and the lactate/pyruvate ratio, whereas pH was elevated These data demonstrate conclusively that one of the main reasons for decreased oxygen supply at the articular surface *after meniscectomies or synovectomies* is excessive intra-articular effusion On the other hand, the rate of accumulation of fluid is likely to depend on the extent *of trauma produced during surgery*

An additional factor decreasing the PO_2 levels, especially after synovectomy, could be increased oxygen utilization by the large surface of healing tissue This *is supported by the fact that the* intra-articular PO_2 declined after synovectomies as healing progressed but remained nearly unchanged in meniscectomized patients The overall high levels *of intra articular PO_2 in both operated* groups in the early postoperative phase were probably *caused by capillary bleeding* after a fresh trauma and also by diffusion of oxygen from the air during operation

Intra articular accumulation of fluid probably produces excessive pressure in the joint cavity and this may inhibit capillary circulation and the supply of oxygen, as well as other *nutrients, to the* repair area Jayson & St John Dixon (1970) demonstrated that the intra articular pressure in the normal knee at

Table 1 Analysis of synovial fluid in non operated patients

	No of patients	Age of patients	Fluid volume (ml)	PO_2 mmHg	PCO mmHg
Trauma *	5	42 ± 11	38 ± 5	28 ± 3	52 ± 4
Synovitis	9	37 ± 6	71 ± 14	12 ± 3	54 ± 3
P (t test)	–	NS	< 0 10	< 0 01	NS

* Duration from trauma to aspiration of fluid 1 to 3 days
Figures indicate the mean ± S F M

rest is approximately atmospheric, and with quadriceps contraction it becomes markedly negative In the presence of effusion, this normal fall in intra-articular pressure is absent, or with larger volumes, reversed, so that a positive pressure results

Postoperative PCO_2 values were elevated in samples with *the largest fluid* volumes (Figure 3), suggesting a decreased removal of CO_2 through the capillary bed The major determinants of hydrogen ion concentration are PCO_2, the amount of lactate and buffering capacity Therefore, as was expected, the accumulation of both CO_2 and lactate was associated with a decrease in pH (Figure 8) The lowest pH levels were observed in the largest fluid samples (Figure 4)

The low intra-articular glucose concentrations observed after synovectomies (Figure 5) could be due to impaired circulation at the surface of the joint cavity Ropes & Bauer (1953) showed an inverse relationship between high intra-articular pressure and synovial fluid glucose concentration and suggested that glucose diffusion in the joint is impaired by blood vessel compression

Results of studies of the concentrations of lactate (Figure 6) and the lactate/pyruvate ratios (Figure 7) showed that increase in the intra articular fluid volume caused a shift of local metabolism towards anaerobic glycolysis This change in cellular metabolism tends to increase the glucose consumption and may, therefore, contribute to the decrease of synovial fluid glucose levels After menisceclomies the levels of the lactate/pyruvate ratio underwent a marked de cline during healing, suggesting a change over to more oxidative metabolism

Obviously, some of the differences in various parameters between joints with *small and large effusions could* be due to qualitative alterations in the composition of intra-articular fluid causing variation in the osmotic pressure Changes in the intra-articular hemoglobin concentration were reflected in corresponding changes in the total protein (Figure 9) Quite expectedly, the fluid hemoglobin levels underwent a gradual decline as post operative bleeding ceased

Synovial fluid analyses in non-operated patients indicated that in traumatic joints the intra-articular PO_2 was excep tionally high (28 mmHg), whereas the lactate/pyruvate ratio was lowest for the whole series (Table 1) On the other hand, in chronic synovitis joints the mean PO_2 was as low as 12 mmHg and the lactate/pyruvate ratio was elevated reaching the levels recorded in post operative fluid samples The protein con tent in traumatic effusions was high due to intra-articular bleeding Synovial fluid glucose concentrations showed no varia tion between the non operated groups

The present work supports and extends the earlier findings suggesting that the very low oxygen tensions found in synovial fluid from joints with chronic synovitis are pathologic (Lund-Olesen

traumatic effusion or chronic synovitis in the knee joint

pH	Glucose mmol/l	Lactate mmol/l	Lactate/ pyruvate	Total protein g/l	Hemoglobin g/l
7 19 ± 0 06	4 60 ± 0 41	3 09 ± 0 65	19 8 ± 1 5	67 0 ± 15 5	36 3 ± 22 3
7 28 ± 0 04	4 40 ± 0 29	3 44 ± 0 23	23 8 ± 1 0	45 3 ± 3 2	0 17 ± 0 12
< 0 10	NS	NS	< 0 05	< 0 05	< 0 05

1970, Treuhaft & McCarty 1971, Falchuk et al 1971) Widespread obliterative endangitis and very high metabolism of synovial tissue observed in rheumatoid arthritis may affect the oxygen supply of the joint and oxygen consumption (Laws et al 1963, Dingle & Page 1956) Direct measurements of *in vivo* oxygen consumption have shown that joints with rheumatoid arthritis utilize two to three times the oxygen of control joints (Goetzl et al 1974 a) Obviously, the white cells present in the joints are not the major determinant of the steady state synovial fluid PO_2 This is supported by the study of Bodel & Hollingsworth (1966) who showed that the respiration of leukocytes in the synovial fluid of rheumatoid joints is less than 50 per cent of that of the leukocytes in peripheral blood

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tric ulceration may result from administration of antiinflammatory drugs such as corticosteroids and salicylates

Confinement to bed can predispose the patient to urinary infection and urinary stone formation The diagnosis and treatment of these changes and complications usually necessitates further X ray investigations

Chronic skeletal disease often affects young people and children These patients are at an early age subjected to a *great number* of radiological investigations The chronic nature of their disease, and the prospect of continuing treatment and X ray investigations of the same patient for many decades, makes knowledge of the accumulated radiation dose important In add[illegible]

[illegible]etal growth by irradiation of the growth zones (*International* Commission on Radiological Protection 1969)

Table 1

Patient no 530202 ♀ R.A	
Onset 1937 at the age of 4 years	
Operations	
Removal of kidney stone	1959
Adductor tenotomy	1962
Total hip replacement	1974
Osteotomy of tibia	1975
Patient no 581002 ♂ *R.A*	
Onset 1960 at the age of 1½ years	
Operations	
Synovectomy both wrists and several finger joints	1967
Resynovectomy one wrist and several finger joints	1968
Adductor tenotomy	1971
Synovectomy both elbows	1971
Synovectomy *of* knee	1973

PATIENTS

This study *comprises* calculations based on published dose values of the total radiation dose absorbed by *two* young patients with juvenile rheumatoid arthritis They were chosen because of their chronic disease, their youth and the exceptionally high number of X ray examinations Both patients have undergone repeated operations (Table 1)

METHODS

Absorbed dose estimation

Radiation absorbed doses in patients from X ray investigations are often reported Apart from skin doses gonad and bone marrow doses are often mentioned However, we have not been able to find any publications dealing with the subject of this article, i.e., the accumulated radiation doses to patients with chronic skeletal disease

Two papers by Hashizume et al (1972 a, b) reporting gonad dose and mean bone marrow dose (local dose to bone marrow averaged over the whole active marrow) were made use of for our calculations The estimated doses in these reports are based on phantom measurements and are given for one radiograph (or fluoroscopy procedure) in different types of examinations and for four different age groups In this study, the ages of the patients at the time of the X ray investigations and the number of radiographs are known Therefore, Hashizume's data are suitable for our calculations Registered gonad doses to men in our hospital (Gustafsson 1976) are in reasonably good agreement with the data of Hashizume et al (1972 a b)

Considering the number of radiographs kept and the age of the patient at the examinations we thus calculated the gonad dose and the mean bone marrow dose for each patient. The results are given in Tables 2 and 3

The absorbed dose from fluoroscopy was estimated according to measurements in our hospital of the total absorbed energy (integral dose) *to* the patient from examinations of the gastrointestinal tract showing that doses from fluoroscopy and radiography are about equal (Gustafsson 1975)

RESULTS

Estimating that one out of six radiographs taken is discarded because of bad quality or because it did not contribute to the making of a diagnosis, the total absorbed doses will be

Patient number	Mean bone marrow dose (rad)	Gonad dose *(rad)*
530202	9.3	12 0
581002	5 8	5.3

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TOTAL RADIATION DOSAGE FROM X-RAY EXAMINATIONS IN RHEUMATOID ARTHRITIS AND OTHER CHRONIC SKELETAL DISEASES

A Study of Two Cases

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Young patients with rheumatoid arthritis and other chronic diseases of the skeleton are increasingly being operated on with replacement of major joints The great number of associated X ray examinations performed on these patients has caused some anxiety amongst orthopaedic surgeons Two patients with juvenile rheumatoid arthritis have been studied An attempt was made to calculate the total radiation dose to bone marrow and gonads For lack of recommendations for the maximum permissible radiation dose to patients the dose calculated has been compared with the maximum permissible dose of radiation workers, and with the dose limit for non occupational irradiation of individuals The yearly absorbed dose in these two patients is much lower than the maximum permissible dose of radiation workers and only slightly higher than the dose limit for non occupational exposure of individuals

Key words bone diseases, chronic disease, radiation dosage, rheumatoid arthritis

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Many patients suffer from chronic skeletal disease with an uncertain prognosis as regards cure, although the disease may not greatly shorten the expected life span Rheumatoid arthritis is a typical example of such a disease

These patients often undergo repeated orthopaedic operations Before being operated on, they are usually X-rayed several times in order to follow the pathological changes Postoperative radiography is often necessary After total hip or knee replacement, X-ray examinations must be done at intervals for a long time, in order to detect complications such as infection, at an early stage The intervals between X-ray examinations vary greatly from one hospital to another

Some of these chronic diseases engaging the skeleton also cause pathological changes in organ systems other than the locomotor system Examples of this are renal amyloidosis in rheumatoid arthritis and aortic insufficiency in ankylosing spondylitis

There may also be adverse effects of the treatment of these diseases, e g , gas

about 32 per cent to the mean bone marrow dose, compared with 23 and 13 per cent, respectively, from hip and pelvis examinations It is also evident that relatively few examinations of the gastrointestinal tract give a high percentage of the absorbed dose

For patient 581002, stomach examinations make the dominating contribution, 35 per cent of the mean bone marrow dose The high gonad dose figure in Table 3 for the knee and foot examinations could well be an overestimation, since no dose values were available for examinations of the knee joint

We also estimated the highest locally absorbed dose in bone marrow This was done in two ways 1) by relating the mean bone marrow dose in Tables 2 and 3 to the distribution of active bone marrow in the body (according to Hashizume et al 1972 b), 2) by using exposure factors and radiation output values according to the International Commission on Radiological Protection (1970) and percentage depth dose factors according to Trout et al (1952) Method 2) gave a 25–50 per cent higher estimated absorbed dose than method 1)

In patient 530202, the lumbar spine received the highest dose about 25 rad and in patient 581002 a maximum absorbed dose of 15 rad was estimated for the lower part of the dorsal spine and upper part of the lumbar spine

Averaged over the period studied, patient 530202 has received about 0 5 rad per year mean bone marrow dose and 0 7 rad per year gonad dose, from X-ray examinations Patient 581002 has received about 0 6 rad per year to bone marrow as well as gonads

DISCUSSION

Radiological effects

The main reason for this study was to estimate the absorbed dose in these young patients from their frequent X-ray examinations When calculating radiation doses in patients we always have the genetic and carcinogenic effects in mind To calculate an expected risk for these patients of radiation induced cancer we would need dose figures also for breasts, lungs, thyroid and other organs and these data are not yet available

Another factor of importance in irradiating children is the potential effect on growth when the growth zones receive high doses The most frequently examined joint in each patient has had 30 to 40 radiographs which should not result in more than 10 rad to the growth zones and probably much less The minimum stunting dose to children has been estimated to be well above 100 rad (International Commission on Radiological Protection, 1969)

Radiation dose from postoperative X-ray investigations

Another point of interest is how much is added to the total radiation doses by the postoperative X-ray examinations Assuming that a patient has both hip joints and both knee joints replaced and there is a postoperative follow up program with five X-ray examinations of each hip and five X ray examinations of each knee, that would add about 0 5 rad to the mean bone marrow dose, about 1 rad to the female gonad dose and about 5 rad to the male gonad dose The male gonad dose could be reduced considerably by using an appropriate gonad shield or by pulling the testes out of the radiation field

Radiation dose comparison

ICRP has not made any recommendations for a maximum permissible radiation dose to patients from X-ray examinations Instead it is stated that 'the level should be as low as is consistent

Table 2 Estimated mean bone marrow dose and gonad dose to patient no 530202, ♀, from X ray examinations performed during the period November 1957–October 1975 (—) means less than 10 mrad

Examination	Number of examinations	Number of radiographs kept	Mean bone marrow dose (mrad)	Gonad dose (mrad)
Heart, lung	23	71	390	140
Cervical spine	8	50	430	—
Dorsal spine	5	19	700	—
Lumbar spine, lumbosacral joints	8	22	920	1460
Hip, pelvis	23	47	1040	2360
Knee, foot	18	74	220	220
Shoulder, arm, hand	10	40	250	—
Urinary tract	31	132	2480	4550
Stomach, abdomen, barium meal	7	36 + fluoroscopy	1140	1310
Others	5	17	150	—
Total	138	508 + fluoroscopy	7720	10040

Table 3 Estimated mean bone marrow dose and gonad dose to patient no 581002, ♂, from X ray examinations performed during the period June 1965–May 1974 (—) means less than 10 mrad

Examination	Number of examinations	Number of radiographs kept	Mean bone marrow dose (mrad)	Gonad dose (mrad)
Heart, lung	22	51	290	40
Cervical spine	8	54	460	—
Dorsal spine	2	6	280	—
Lumbar spine	3	12	500	240
Hip pelvis	4	9	260	1170
Knee, foot	19	122	220	2130
Shoulder, arm, hand	25	121	820	—
Urinary tract	1	14	240	150
Stomach abdomen	5	36 + fluoroscopy	1660	650
Others	3	9	70	—
Total	92	433 + fluoroscopy	4800	4380

These figures should only be regarded as rough estimates of the real absorbed doses Recalculations were done from median values of gonad doses reviewed by United Nations Scientific Committee on the Effects of Atomic Radiation (1972) and from bone marrow dose estimations for the United Kingdom (Committee on Radiological Hazards to Patients 1966) and the Netherlands (Weber 1964) The greatest deviation found was a 70 per cent higher mean bone marrow dose calculated from the U K data for patient no 530202 This difference is partly explained by the fact that the U K data are not specified for children

From Table 2, for patient 530202, it can be seen that examinations of the urinary tract contribute about 45 per cent to the estimated gonad dose and

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PAIN INDUCED CHANGES IN THE KNEE JOINTS ADULT RABBITS

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mo, Sweden

Rapidly progressing joint disease can be produced in the rabbit by intra articular injection of concentrated papain With the use of radioactive thymidine it is possible to demonstrate that the cartilage cells recover their ability to divide by mitosis at the same time as degenerative changes appear in the cartilage Clusters of chondrocytes arise by mitosis of chondrocytes and not by a floating together of cartilage cells

Key words papain, cartilage, experimental osteoarthritis, mitoses, autoradiography

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erimental osteoarthritis can be in-ed in various ways In recent years enerative joint changes have been luced by excision of part of the joints ll 1969, Thompson & Basset 1970), l traumatization of the joint cartilage nnet et al 1932, Carlson 1957, chim 1963, Campbell 1969 and Lem g et al 1971), compression (Crelin & thwick 1960, 1964, Ginsberg et al 9, Thompson & Bassett 1970) or im-bilization of the joints (Evans et al 0, Hall 1963, 1964) or by dislocation the patella (Bennet & Bauer 1937) By dering a joint unstable (Marshall & son 1971, Telhag & Lindberg 1972), it possible to produce joint changes re mbling those seen in human osteo hritis (according to Collins 1949) th flaking, fibrillation and erosion of e articular cartilage

ancial support was obtained from Herman nhardts Stiftelse Alfred Österlunds Stiftelse d Ulla och Gustaf af Ugglas fond

Proteolytic enzymes release chondroitin sulphate from the protein-polysaccharide complex in the matrix Papain is a proteolytic enzyme, and when given intravenously or intra-articularly in rabbits, it causes joint changes similar to those seen in human osteoarthritis (Murray 1964, Bentley 1971, Farkas et al 1974)

It has been shown that when degenerative changes develop in the joint cartilage in man and in the rabbit, the condrocytes recover their ability to synthetize DNA, i e, to divide (Hulth et al 1972, Telhag 1972) It has hitherto not been possible to demonstrate with certainty the presence of mitotic figures in normal joint cartilage in adult human beings or animals (Mankin 1963, 1964, 1968, Hulth et al 1972, Telhag 1972, 1973)

The purpose of this investigation was to find out whether chondrocytes recover their ability to divide after intra-articular injection of papain, and to elucidate

with obtaining the required diagnostic information" (International Commission on Radiological Protection, 1970)

The International Commission on Radiological Protection recommendations for exposure of individuals (International Commission on Radiological Protection, 1966) implies that the maximum permissible dose to radiation workers is 5 rad per year and that no individual should receive more than 0 5 rad per year non-occupationally Excluded from these yearly doses are natural irradiation and irradiation of a person as a patient These dose limits are set for planning purposes and at levels considered to result in acceptable risks for radiological effects

The average yearly doses of 0 5–0 7 rad to gonads and bone marrow calculated for the two patients could also be compared with the mean absorbed dose from natural sources which is about 0 09 rad per year (United Nations Scientific Committee on the Effects of Atomic Radiation, 1972)

Follow-up X-ray investigations

When planning a follow-up program, for instance after total hip replacement, the frequency of the X-ray examinations must be determined Various factors should be considered, not only the type of operation done and the complications that may arise but also the age of the patient and the total radiation dose In a follow-up program for young patients it is especially important to minimize the absorbed dose from X-ray examinations This is done by effective shielding of organs not being examined, by reducing the number of projections and by using the most sensitive X-ray recording system that gives the information required

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This study, which is part of a project concerning hip surgery in rheumatic diseases was financially supported by grants from Riksbundet mot reumatism, Foreningen for bis... At vanfora i Skåne, and Signe och Ra... Sunds stiftelse

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Rapidly progressing joint disease can be produced in the rabbit by intra articular injection of concentrated papain With the use of radioactive thymidine it is possible to demonstrate that the cartilage cells recover their ability to divide by mitosis at the same time as degenerative changes appear in the cartilage Clusters of chondrocytes arise by mitosis of chondrocytes and not by a floating together of cartilage cells

Key words papain cartilage, experimental osteoarthritis, mitoses, autoradiography

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[illegible]perimental osteoarthritis can be in-[illegible]ced in various ways In recent years degenerative joint changes have been produced by excision of part of the joints (Hall 1969, Thompson & Basset 1970), local traumatization of the joint cartilage (Bennet et al 1932, Carlson 1957, Meachim 1963, Campbell 1969 and Lemperg et al 1971), compression (Crelin & Southwick 1960, 1964, Ginsberg et al 1969, Thompson & Bassett 1970) or immobilization of the joints (Evans et al 1960, Hall 1963 1964) or by dislocation of the patella (Bennet & Bauer 1937) By rendering a joint unstable (Marshall & Olsson 1971, Telhag & Lindberg 1972), it is possible to produce joint changes resembling those seen in human osteoarthritis (according to Collins 1949) with flaking fibrillation and erosion of the articular cartilage

Proteolytic enzymes release chondroitin sulphate from the protein polysaccharide complex in the matrix Papain is a proteolytic enzyme, and when given intravenously or intra articularly in rabbits, it causes joint changes similar to those seen in human osteoarthritis (Murray 1964, Bentley 1971, Farkas et al 1974)

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recover their ability to synthetize DNA, i e, to divide (Hulth et al 1972, Telhag 1972) It has hitherto not been possible to demonstrate with certainty the presence of mitotic figures in normal joint cartilage in adult human beings or animals (Mankin 1963, 1964, 1968, Hulth et al 1972, Telhag 1972, 1973)

The purpose of this investigation was to find out whether chondrocytes recover their ability to divide after intra articular injection of papain, and to elucidate

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the histological development of papain-induced joint changes

MATERIAL AND METHODS

The material consisted of 16 full grown (grey Silver) rabbits with roentgenographically closed epiphyseal lines They were caged under normal conditions and fed on normal diet The animals weighed 2 010–2 960 g (mean 2 468) They were divided into two groups The first group (12 animals) received 0 2 ml concentrated, sterile papain in the right knee joint, and the left served as a control They were killed two at a time, 2, 3, 5 days and 1, 2 and 4 weeks after the injection of papain The second group (4 animals) received 0 2 ml of a 20 per cent solution of concentrated, sterile papain in the right knee joint, and the left served as a control They were also killed two at a time, 2 and 4 weeks after the injection of papain Four hours before sacrifice, 40 μCi ^{3}H thymidine was injected intra articularly into both knee joints of the animals studied for 1, 2 and 4 weeks The animals studied for 2, 3 and 5 days received two doses of ^{3}H-thymidine, each consisting of 40 μCi, intra articularly into both knee joints, 24 and 18 hours, respectively, before sacrifice

The animals were killed with an overdose of Nembutal i v (Abbott) None of the joints showed any signs of infection Both knee joints were dissected and fixed in 10 per cent formalin solution The patella, tibia and femur were dissected free and treated separately The tibia and the femur were divided into two halves in the frontal plane with a circular saw The pieces were decalcified in 50 per cent formic acid and 20 per cent sodium citrate They were embedded in paraffin and cut into sections 5 7 μ thick

The sections were stained with haematoxylin eosin, safranin O and according to van Gieson Autoradiograms of routine histological sections were prepared from both knees according to the dipping method with Ilford K2 liquid emulsion The autoradiograms were exposed for 3 weeks after which they were developed in Gevaert X ray developer G 230 and fixed in Gevaert X ray fixer G 350 The sections were stained through the emulsion with Mayer s haematoxylin As a rule three autoradiograms from the tibia femur and patella of both knee joints from each animal were examined

RESULTS

The animals showed no signs of a generalized toxic reaction to the injection of papain In fact, the animals did not seem to spare the treated knee, and all of them survived the experimental period

Histological examination

None of the left control knees showed any evidence of degeneration In one of the animals, receiving concentrated papain, a little osteoblastic activity was seen at the margin The sections stained with Safranin-O showed normal staining properties of the matrix except for three animals given concentrated papain and killed 2 weeks (1 rabbit) and 4 weeks (2 rabbits) later In these animals the matrix had lost the staining properties seen in all the other animals

Findings 2 days after injection of concentrated papain At the margins there was slight proliferation of cells in and near the perichondrium and periosteum but there were no signs of osteoblastic activity or new bone formation The articular cartilage showed signs of degradation in both the animals In one knee joint almost all the cartilage was necrotic The degradation was reflected in death of cells, mostly in the columnar and transitional layers, whereas the superficial layer was normal Thus, the cell nuclei stained weakly or not at all, and it was often difficult to distinguish the cell membrane from the surrounding matrix No clusters were seen In one animal there was flaking and fibrillation of the surface

Findings 3 days after injection of concentrated papain At the margins and in the tissue adjacent to the cruciate ligaments, there was proliferation of cells and the beginnings of osteoblastic activity in both animals The degradation of the articular cartilage seemed to be more pronounced than at 2 days after the papain injection, with flaking of the superficial layer and fibrillation The death of the chondrocytes could be seen down to the tidemark No clusters were seen



Figure 1 One week after injection of concentrated papain The articular cartilage is almost totally necrotic Single clusters flaking and fibrillation Magnification × 72

Findings 5 days after injection of concentrated papain The proliferation of cells at the margins and adjacent to the cruciate ligaments and the osteoblastic activity, were still more pronounced This was also true of the changes in the cartilage Flaking of the superficial layer and fibrillation could be seen Deeper down in the cartilage total necrosis was seen and only a few chondrocytes Clusters were not seen

Findings 1 week after injection of concentrated papain At the margins and to some extent in the tissues adjacent to the attachments of the cruciate ligaments there was proliferation of cells in and near the perichondrium and periosteum Furthermore most of the specimens showed ingrowth of capillaries with osteoblastic activity sometimes with signs of new bone formation The articular cartilage almost always exhibited signs of degradation in both knee joints from each animal in one knee joint almost the entire cartilage was necrotic Degradation was reflected in the death of cells mostly in the non calcified layers of cartilage and particularly so in the columnar layer Thus the cell nuclei stained only weakly or not at all and it was often difficult to distinguish the cell membrane from the surrounding matrix In one of the two knees there were clusters of chondrocytes as well as flaking of the outer layer of the cartilage and fibrillation, sometimes down to the calcification line (Figure 1)

Findings 2 weeks after injection of concentrated papain At the margins and at the attachments of the cruciate ligaments, granulation tissue had formed with abundant fibrous cells and vessels, and the osteoblastic activity with new bone formation was much more striking than that seen 1 week after the injection In some of the specimens osteophytes had begun to form at the margins The degradative changes had continued to progress The articular cartilage showed severe changes often with total necrosis of the cartilage and only a few chondrocytes Clusters were seen only in occasional sections, as were flaking and fibrillation

Findings 2 weeks after injection of 20 per cent papain At the margins and at attachments of the cruciate ligaments, granulation tissue had formed and abundant osteoblastic activity was seen with new bone formation and in some slides osteophytes had begun to form The degradative changes of the cartilage were not as pronounced as when concentrated papain was injected The changes were

Figure 2 Two weeks after injection of 20 per cent papain The articular cartilage of the transitional and columnar layers is almost totally necrotic Single clusters Magnification × 28



mostly limited to the transitional and columnar layers (Figure 2), whereas they were not so pronounced in the superficial layer On the other hand, flaking and fibrillation were seen, as were clusters

Findings 4 weeks after injection of concentrated papain Histologically, the formation of osteophytes at the margins as well as the subchondral osteoblastic activity were more prominent Some specimens also showed new bone formation subchondrally, although no definite evidence of sclerosis was seen The cartilage was often completely necrotic, far down in the columnar layer, in some areas down to the calcification line, and occasionally the calcified cartilage was changed Flaking, fibrillation and clusters were rare Living chondrocytes were sparse

Findings 4 weeks after injection of 20 per cent papain The proliferation of cells at the margins and at the attachments of the cruciate ligaments was still more pronounced than 2 weeks after the injection, as was also the osteoblastic activity Subchondrally, new bone formation was seen, and at the margins formation of osteophytes had begun The degradative changes of the cartilage were less than after the injection of concentrated papain The articular cartilage was not totally necrotic but in some places necrosis of the chondrocytes was seen Big clusters as well as flaking and fibrillation were observed

Autoradiographic evaluation

Specimens from 8 of the 16 control knees (left) showed fairly sparse thymidine labelled chondrocytes All 8 belonging to group 1 (right knee joint injected with concentrated papain) In none of the control knees belonging to group 2 (20 per cent papain injected into the right knee joint) were any thymidine-labelled chondrocytes found

In *group 1 (concentrated papain)* sparse labelled chondrocytes were found in the articular cartilage in two knees but there was only inconclusive evidence of this in the other four knees, when the animals were killed 2, 3 and 5 days after the injection Seven days after the injection, one of the knee joints contained abundant labelled chondrocytes but the other contained fairly sparse labelled cells

Fourteen days after the injection of concentrated *and 20 per cent papain* rather abundant labelled chondrocytes were found, especially in the latter group where the cell necrosis was not so pronounced In the group injected with concentrated papain and killed 4 weeks later, only sparse labelled *chondrocytes* were found

The labelled chondrocytes were usually situated in the superficial and transitional layers but also in the columnar layer Clusters with labelled chondrocytes were also seen

DISCUSSION

The availability of an experimental model is valuable in the investigation of the pathophysiology of osteoarthritis and the evaluation of therapeutic methods

It has been shown (Bentley 1971, Farkas et al 1974) that degenerative and reparative changes resembling those in

concentrated papain caused rapidly progressing necrosis of the joint cartilage within 2 days, and after 4 weeks the non-calcified cartilage, and sometimes also the calcified layer, were so severely damaged that only occasional apparently viable chondrocytes were demonstrable After the injection of 20 per cent papain, the changes in the articular cartilage were not so pronounced as when concentrated papain was injected, the changes being more of a degenerative nature Like Bentley, we also found that chondrocytes in the deeper columnar layer were more affected than those in the superficial and transitional layers

One week after the injection, the specimens showed abundant clusters of chondrocytes With increasing time after the papain injection the number as well as the clusters of chondrocytes decreased, being less pronounced after injection of 20 per cent papain Especially at 4 weeks after injection of 20 per cent papain, big clusters were seen Collins & McElligot (1960) found some evidence of proliferation of chondrocytes and clusters in osteoarthritis Bentley (1971) described such clusters within 24 hours of an injection of papain into hip joints in the rabbit but we could not find any clusters until 1 week after the injection Bentley assumed that clusters were due to an aggregation of chondrocytes, secondary to loss of matrix He felt that this could explain the development of clusters in osteoarthritis Farkas et al (1974), on the other hand, found chondrocyte clusters with mitotic figures in the haematoxylin-eosin sections

When degenerative changes of the articular cartilage are produced experimentally (Telhag & Lindberg 1972), mitosis of the chondrocytes is not seen until 5 days after the operation Therefore, animals killed before 1 week were given 2 injections of titriated thymidine

It has been shown that clusters can take up radioactive thymidine in degenerative joint disease both in the rabbit and in man (Hulth et al 1972, Telhag 1972) This was confirmed in the present investigation, in which it was shown that when degenerative changes of the cartilage occur the chondrocytes recover their ability to divide and, when situated in clusters, possess the ability to take up radioactive thymidine This suggests that clusters arise from division, and not by 'a floating together' of cartilage cells Thus, any type of damage of the joint cartilage stimulates the S phase of the mitotic cycle of the chondrocytes

Mitosis of chondrocytes in the normal adult joint cartilage has hitherto not been demonstrated with certainty in animals or in man (Mankin 1963, 1964, 1968, Hulth et al 1972, Telhag 1972, 1973) When concentrated papain was given in the right knee, we found some labelled cartilage cells in the control knees, which might possibly have been due to a minute portion of the papain having been transported there This perhaps also explains the negative safranin O staining in three of the control knees injected with concentrated papain A technical fault can, however, not be excluded

Bentley (1971) demonstrated formation of osteophytes resembling those seen

in human osteoarthritis after injection of papain Such formation was verified in the *present investigation* Four weeks after the injection of papain, the specimens exhibited incipient formation of osteophytes of the same appearance as those seen in human osteoarthritis according to Collins (1949), and in experimental osteoarthritis in the rabbit (Telhag & Lindberg 1972).

Many methods have been used for inducing osteoarthritic lesions in the joints With *papain, it is possible to produce* advanced joint changes In the present investigation, rapidly progressing changes in the articular cartilage were produced by the injection of concentrated papain The changes produced in the articular cartilage seem to be of necrotic rather than of a degenerative nature Papain, in lower concentrations, produces lesions more similar to those seen in human osteoarthritis thus also providing a possibility to study the earlier changes of degeneration and repair Consequently, the method would appear to be useful for studying the metabolism of the joint cartilage in the early stages of joint disease.

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POROUS CERAMICS AS A BONE SUBSTITUTE IN THE MEDIAL CONDYLE OF THE TIBIA

An Experimental Study in Sheep Long-Term Observations

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A recent 3 month implantation study indicated that a new porous ceramic material might be suitable as a bone substitute in regions exposed mainly to compressive forces The porous ceramics were implanted into the medial condyle of the tibia of sheep In the present study the implants were left for 10 months in three animals, and 12 months in two In the two animals with 12 months' observation, the plate which had been used to stabilize the implant was removed at 10 months The implants and the adjacent bone tissue were studied macroscopically, radiographically and by microradiography and transmitted light microscopy All the implants were bound to the adjacent bone by ingrowth of bony tissue The depth of the bony invasion was slightly greater than that observed at 3 months, being maximally 3–4 mm Some signs of ossification were still seen within the pores. The bony bridges between the implants and the surrounding bone were particularly well developed in regions of maximal stress This was interpreted as a sign of active adaption of the bone formation to the actual stress to which the shearing surfaces were exposed It is concluded that the properties of the porous ceramic implants justify a clinical trial in man

Key words bone substitute, porous ceramics, tibial condyle fracture

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In a previous study (Benum et al 1976) a new porous ceramic material was tested for possible use as a bone substitute in regions exposed mainly to compressive forces The porous ceramics which mainly consisted of Al_2O_3 were implanted into the medial condyle of the tibia in sheep and left in position for 3 months The implants were found to be bound to the adjacent bone by ingrowth of bony tissue It was concluded that a clinical trial was justified if the results of long-term observations proved equally satisfactory

In the present investigation we have studied the fate of the implants for up to 12 months and have paid particular attention to the anchorage of the implants to the surrounding bony tissue

MATERIAL AND METHODS

The implants were similar to those used in the short term observations The pore size was 100–1000 μ (Benum et al 1976)



Figure 1 Radiographs of an implant 12 months postoperatively The plate which was used to keep the implant in position was removed 2 months prior to sacrifice A Frontal view B Medial view. There is no sign of collapse of the tibial plateau and no sign of osteolysis around the implant.

Animals

Six female sheep, weighing 45–60 kg, were used Their age varied from 6 to 8 years epiphyseal fusion of the tibia had occurred in all animals

Surgical procedure, postoperative regimen

The operations were performed in exactly the same manner as described earlier, the postoperative regimen was also unchanged (Benum et al 1976) One animal died of intercurrent disease the five others appeared *totally* unaffected by the operation

Investigative procedure

Three animals were sacrificed 10 months *after* operation In the remaining two the operated knee was X-rayed at 10 months, the AO-fingerplate was then removed, and the animals allowed to resume their normal activities for another 2 months before they were sacrificed

After sacrifice the operated knee and the proximal part of the tibia were removed and inspected, the specimens were fixed in formaldehyde, X rayed and dehydrated in alcohol, and finally embedded in methylmethacrylate as described earlier (Benum et al 1976)

The subsequent investigative procedure was also similar, except that all sections were cut in the coronal plane

Contact micro radiographs were taken of 300 μ thick sections, as described by Jowsey et al (1965) The sections were then ground down to a thickness of 40–50 μ and stained with Paragon

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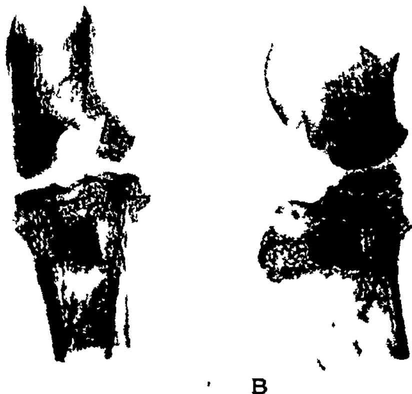


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1301 ("Paragon PS 1301", Paragon C & Co, 1 nc, Bronx, NY, USA)

Both contact micro radiographs and stained sections were examined by light microscopy

RESULTS

Function and macroscopic appearance

All the surviving animals recovered normal function after the operation At sacrifice there were no signs of local infection or reaction around the implants All the implants appeared firmly anchored to the surrounding bone, and there were no macroscopic signs of fracture of the implants or the tibial condyles

Radiological examination

No signs of fracture or collapse of the impants or the tibial condyles were seen at sacrifice There were no signs of resorption of bone above or below the implants In the two cases where the plate had been removed 2 months prior to sacrifice, no radiographic changes were seen after removal of the plate (Figure 1)

Microradiography

The findings were almost identical in all the animals In all parts of the implants which were in contact with bone, all surface irregularities and the most peripheral pores appeared to be filled with bone The invasion of bony tissue was most extensive in the part of the implants which rested upon the supporting peripheral ring of cortical or cancellous bone The maximal depth to which the pores appeared to be filled with bone was 3–4 mm The depth of bone invasion was considerably less in the superior surface of the implants Here the ingrowth of bone appeared most pronounced along the periphery of the implants, in particular medially

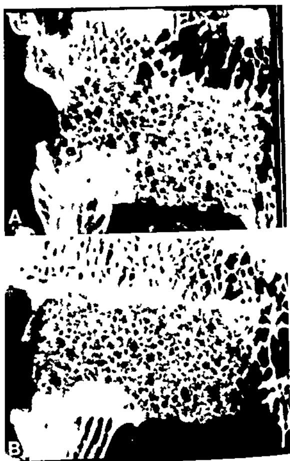


Figure 3 Microradiographs of sections through an implant Observation period 10 months (× 2 5) A From the transition zone between the anterior and middle third of the implant B From the most posterior region Ingrowth of bone is most extensive in the area corresponding to the supporting peripheral ring of bone The maximal depth of bone invasion is approximately 4 mm (A) On the superior surface of the implant the bone invasion is also most pronounced medially In both microradiographs the adjacent bone at the undersurface appears thickened

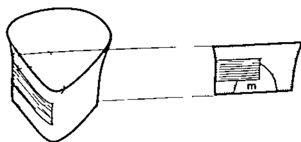


Figure 2 Schematic illustration of a specimen and a section removed from the middle part of the implant The dotted area represents bony tissue m medullary cavity (The anterior and posterior regions and also the lateral part of the implant were surrounded by bone)



Figure 4 Microradiographs of sections of an implant (same implant as Figure 1) at 12 months (× 4) The microradiographs demonstrate the ingrowth of bone in the most anterior part (A) and further posteriorly to the most posterior part (F) The relation of bone invasion to the adjacent bone is similar to that shown in Figure 3 but the extent of the invasion is slightly less pronounced There is no ingrowth of bone in those parts of the implant which are not in contact with bone

1301 (Paragon PS 1301 Paragon C & Co Inc Bronx NY USA)

Both contact microradiographs and stained sections were examined by light microscopy

RESULTS

Function and macroscopic appearance

All the surviving animals recovered normal function after the operation At sacrifice there were no signs of local infection or reaction around the implants All the implants appeared firmly anchored to the surrounding bone and there were no macroscopic signs of fracture of the implants or the tibial condyles

Radiological examination

No signs of fracture or collapse of the impants or the tibial condyles were seen at sacrifice There were no signs of resorption of bone above or below the implants In the two cases where the plate had been removed 2 months prior to sacrifice no radiographic changes were seen after removal of the plate (Figure 1)

Microradiography

The findings were almost identical in all the animals In all parts of the implants which were in contact with bone all surface irregularities and the most peripheral pores appeared to be filled with bone The invasion of bony tissue was most extensive in the part of the implants which rested upon the supporting peripheral ring of cortical or cancellous bone The maximal depth to which the pores appeared to be filled with bone was 3.4 mm The depth of bone invasion was considerably less in the superior surface of the implants Here the ingrowth of bone appeared most pronounced along the periphery of the implants in particular medially

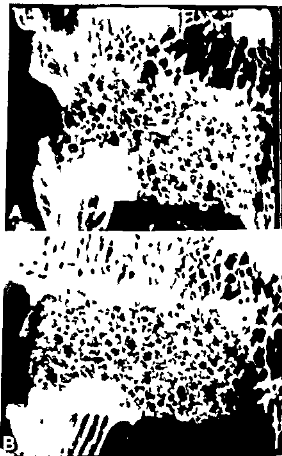


Figure 3 Microradiographs of sections through an implant Observation period 10 months (× 2.5) A From the transition zone between the anterior and middle third of the implant B From the most posterior region Ingrowth of bone is most extensive in the area corresponding to the supporting peripheral ring of bone The maximal depth of bone invasion is approximately 4 mm (A) On the superior surface of the implant the bone invasion is also most pronounced medially In both microradiographs the adjacent bone at the undersurface appears thickened

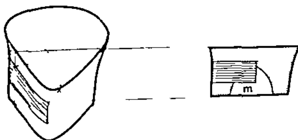


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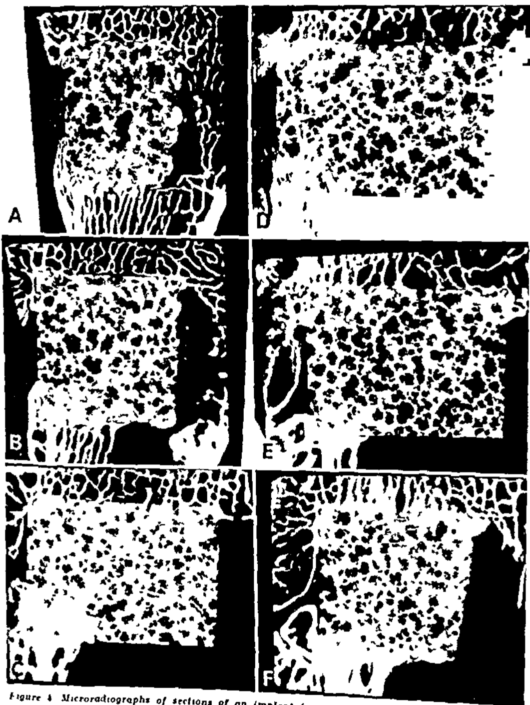


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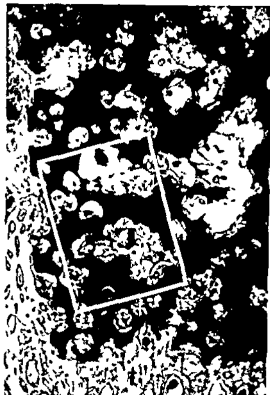


Figure 5 A General view from the lower part of the implant (× 11 5) The picture demonstrates that the pores of the lower part of the implant are filled with bone The pores of the more central region are filled with connective tissue (Compare Figure 5, B and C) The lower part of the implant is completely surrounded by bone The bone trabeculae (t) of the adjacent bone are directly continuous with those of the bone within the pores (details in Figure 5 B)

Figure 5 Photomicrographs of a slide from the anterior part of an implant The slide was prepared from the section demonstrated microradiographically in Figure 4 A (Paragon)



Figure 5 B Detail from the lower part of Figure 5 A (× 28)

The adjacent bone was markedly thickened on the undersurface of the implants, corresponding to the area of maximal invasion This was particularly true in the supporting peripheral ring of bone (Figures 3 and 4)

Histological examination

The histological examination verified the occurrence and distribution of bony tissue as found by the microradiographic investigation The most peripheral pores were completely filled with bone in all areas of the implant surrounded by bony tissue, and bony invasion in the deeper pores was found in the area adjacent to the peripheral ring of cortical or cancellous bone Generally no connective tissue was seen interposed between the bony tissue and the ceramics in these regions Most parts of the bony tissue appeared trabecular. The trabeculae of the adjacent bone were directly continuous with those of the new bone in the pores (Figure 5, A and B) Occasionally Haversian channels could be observed (Figure 5 D) In the central regions of the implants, and in those parts of the implants which were not adjacent to bone, the pores appeared to be filled with connective tissue (Figure 5 C) Occasionally narrow bone trabeculae surrounded by connective tissue were seen in these regions

Osteoblasts and osteoid tissue were found on the surface of the bone trabeculae in some pores, indicating appositional bone growth (Figure 5 E) Intramembranous



Figure 5 C Detail from the area demarcated in Figure 5 A (× 28) The occurrence of bone (b) within the lower pores and connective tissue (c) within the overlying pores (details in Figure 5 I) are demonstrated



Figure 5 D This picture demonstrates a Haversian channel (indicated by arrow) (× 115)



Figure 5 E A row of osteoblasts (indicated by arrow) on the surface of the bone trabeculae (b) The dark zone between the osteoblasts and the bone represents osteoid tissue (× 115)



Figure 5 F Demonstrating intramembranous ossification Osteoblasts (indicated by arrow) are seen at the border between the connective tissue (c) and the intramembranous bone (b) The dark zone lining the bone represents osteoid tissue (× 115)

ossification was seen within some of the pores which contained connective tissue (Figure 5) Osteoclasts were rarely observed

The connective tissue within the pores was generally well vascularized and contained fibroblasts (Figure 5, I and J) No special infiltration of round cells or

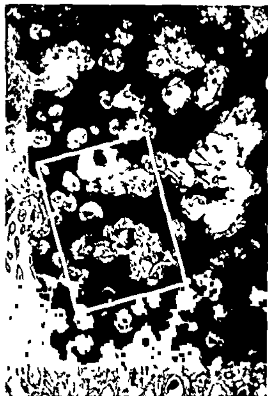


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was only slightly greater at 10 and 12 months compared with that at 3 months However, the bone bridges between the host bone and the implants correspond ing to the areas of high stress had devel oped considerably It seems reasonable to assume that the bone formation within the pores during the earliest period after implantation represents a phase of un organized callus formation Remodelling then probably takes place due to the actual mechanical stress on the bone bridges between the bone and the im plant Such remodelling is of the utmost importance, not only if porous ceramics are to be used as a bone substitute, but even more so if this material should be employed in fixation of endoprostheses

In the present experiments the connective tissue appeared highly active met abolically being vascular and rich in fibroblasts Intramembranous bone for mation was observed within this tissue and appositional trabecular bone forma tion was still taking place It seems unlikely, however, that larger porous ce ramic implants would become completely filled with bone, if applied clinically Hence the strength of such impants can not be expected to increase significantly with the invasion of bone According to the specifications of compressive strength given earlier (Benum et al 1976) it seems unlikely however, that the porous ceramics should be weaker than the sur rounding cancellous bone if used as a bone substitute in regions mainly ex posed to compressive forces The com pressive strength of the porous ceramics employed in our studies compares fa vourably with the strength of cancellous bone in the tibial condyles reported by other investigators (Behrens et al 1974)

Porous alumina ceramics have previ ously been found to be chemically inert and it has further been shown that such ceramics do not produce any significant adverse reactions after implantation (Klawitter et al 1969, Hulbert et al 1970, 1972, Rhinelander et al 1971, Nilles et al 1973) The findings of the present study, that osteocytes were lying close to the ceramics without interposition of con nective tissue, and furthermore the lack of significant foreign body reactions around or within the implants, confirm that the ceramics possess a high degree of biocompatibility

Due to the present knowledge of the properties of porous ceramics we feel that a clinical trial of porous ceramics as a bone substitute in regions mainly ex posed to compressive forces is justified

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Figure 5 G Detail from the contact area between bone and ceramics No connective tissue is interposed between the bone (b) and the ceramics (ce) The osteocytes are lying close to the ceramics (× 360)

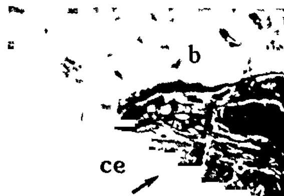


Figure 5 H Foreign body cells (indicated by arrow) lying between the bone (b) and the ceramics (ce) (The picture is overexposed in order to distinguish the cells from the dark surroundings) (× 360)



Figure 5 I This picture shows highly vascular connective tissue within a pore (× 15)



Figure 5 J Detail from Figure 5 I demonstrating that the connective tissue contains a considerable number of fibroblasts (× 360)

leucocytes indicating inflammatory reaction could be observed within the implants Osteocytes were observed close to the ceramics (Figure 5 G), in some regions, however, some foreign body cells could be observed (Figure 5 H)

There were no changes in the implants observed for 12 months which indicated loosening after removal of the plate

DISCUSSION

We have previously reported that after 3 months porous ceramic implants were found to be bound to the adjacent bone by ingrowth of bony tissue, in some regions to a depth of 2–3 mm Some osteoid tissue and signs of osteoblastic activity were still seen (Benum et al 1976)

In the present study some ossification was still taking place within some pores of the implants Since osteoclasts were rarely observed, it seems reasonable to assume that the appositional bone formation on the surface of the bone trabeculae leads to an increased bone mass, and not only reflects a process of remodelling The finding of intramembranous ossification undoubtedly indicates that bony tissue is still being formed within pores previously occupied by connective tissue

The maximal depth of bone invasion

was only slightly greater at 10 and 12 months compared with that at 3 months However the bone bridges between the host bone and the implants corresponding to the areas of high stress had developed considerably It seems reasonable to assume that the bone formation within the pores during the earliest period after implantation represents a phase of unorganized callus formation Remodelling then probably takes place due to the actual mechanical stress on the bone bridges between the bone and the implant Such remodelling is of the utmost importance not only if porous ceramics are to be used as a bone substitute but even more so if this material should be employed in fixation of endoprostheses

In the present experiments the connective tissue appeared highly active metabolically being vascular and rich in fibroblasts Intramembranous bone formation was observed within this tissue and appositional trabecular bone formation was still taking place It seems unlikely however that larger porous ceramic implants would become completely filled with bone if applied clinically Hence the strength of such impants can not be expected to increase significantly with the invasion of bone According to the specifications of compressive strength given earlier (Benum et al 1976) it seems unlikely however that the porous ceramics should be weaker than the surrounding cancellous bone if used as a bone substitute in regions mainly exposed to compressive forces The compressive strength of the porous ceramics employed in our studies compares favourably with the strength of cancellous bone in the tibial condyles reported by other investigators (Behrens et al 1974)

Porous alumina ceramics have previously been found to be chemically inert and it has further been shown that such ceramics do not produce any significant adverse reactions after implantation (Klawitter et al 1969 Hulbert et al 1970 1972 Rhinelander et al 1971 Nilles et al 1973) The findings of the present study that osteocytes were lying close to the ceramics without interposition of connective tissue and furthermore the lack of significant foreign body reactions around or within the implants confirm that the ceramics possess a high degree of biocompatibility

Due to the present knowledge of the properties of porous ceramics we feel that a clinical trial of porous ceramics as a bone substitute in regions mainly exposed to compressive forces is justified

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PAIN RELIEVING EFFECT OF SCALENOTOMY

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A follow-up was made of 37 patients treated by section of the anterior scalenus muscle They complained of pain and/or paraesthesia in the upper extremities and tenderness over the muscle All experienced relief of pain after injection of a local anaesthetic into the anterior scalenus muscle Twenty-five patients were markedly improved Patients with neurological signs seem to have a better result than those without ($P = 0.06$)

Key words scalenus anticus syndrome

Accepted 18 i 77

In patients with widely distributed pain or paraesthesia in the upper extremities the causal factor can be difficult to localize A review is presented of 37 patients who were treated with scalenotomy, after an injection of local anaesthetic into the anterior scalenus muscle had given relief of pain or paraesthesia

PATIENTS AND METHOD

All patients who underwent anterior scalenotomy from 1 April 1961 to 30 June 1975 have been reviewed All had pain and/or paraesthesia in the upper extremity and tenderness over the anterior scalenus muscle except for three, who have been excluded

The investigation includes 37 patients on whom 38 scalenotomies have been performed The results of the operation were judged partly by the most recent notes in the case records—on an average 110 days (3–350 days) postoperatively—and partly from a questionnaire which was returned by 36 patients an average of 54 months (5–168 months) postoperatively

RESULTS

Sex and age distributions in the patients are shown in Figure 1 Their symptoms, signs and X-ray findings are included in Tables 1–3 Neurologic signs were found in 16 patients Weakening of the hand shake was seen in eight patients, and one patient had weakened flexion/extension of the elbow joint Several patients presented with atrophy, two had atrophy of the thenar muscles, one of the hypothenar muscles, one of the interosseous muscles and one of the upper arm The results of the operation are shown in Tables 4 and 5 Because of the two maxima in the age distribution curve we divided the patients into two groups one including patients younger than 30 years, the other one those older than 30 We analysed signs and efficacy of the operation in the two groups separately Then they were compared according to the hypergeometric distribution (Therkelsen 1974) There was no difference in signs between the two groups *The result* of the operation was statistically better in the younger group, comparing the statements in the case records ($P = 0.005$), but there was no difference if comparison was made of the questionnaires ($P > 0.15$) Patients with neuro-

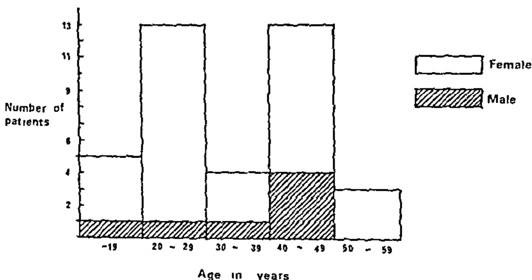


Figure 1 Sex and age distribution

logic signs seem to be relieved more often than patients without ($P = 0.06$) There was no difference in the efficacy of the operation between patients with or without cervical rib When present, it was never removed The patients had had symptoms for an average of 2½ years before the operation (1 month–15 years)

Table 1 Symptoms

Diffuse pain or paraesthesia	19
Rad[illegible]	[illegible]

Table 2 Physical signs

	Present	Not present	No information in the case record
Hypaesthesia	12	22	4
Paresis	9	17	12
Muscle atrophy	5	27	6
Muscle atrophy	18	13	7

Table 3 X ray changes

No abnormality	21
Cervical rib	8
Cervical spondylosis	3
Large transverse process of c VII	6

Table 4 The effect of scalenotomy as judged by the replies to the questionnaire

	Patients older than 30 years	Patients younger than 30 years	In all
No symptoms	4	1	5
Negligible symptoms	7	12	19
Unchanged symptoms	6	4	10
Aggravation	1	1	2

Table 5 The effect of scalenotomy as judged by the report in the case record

	Patients older than 30 years	Patients younger than 30 years	In all
No symptoms	3	3	6
Negligible symptoms	6	13	18
Unchanged symptoms	11	2	13
Aggravation	0	0	0

DISCUSSION

In patients with pain or paraesthesia in the upper extremity, with tenderness over the anterior scalenus muscle, the diagnosis of "scalenus (anticus) syndrome" was made when no other obvious cause, as for instance cervical disc syndrome, was found (Naffziger & Grant 1938, Judovich et al 1944, Shenkin & Somach 1963) However, Shenkin & Somach (1963) stated that the signs alone were insufficient for the diagnosis At the Orthopaedic Hospital, in Aarhus, we agree with this and have used injection of a local anaesthetic (1 per cent *Lidocaine*) to relax the muscle and to see whether this would relieve the symptoms In other clinics the physical examination has been supplemented by subclavian arteriography (Somerndike et al 1973) and ulnar nerve trunk conduction studies (Krogness 1973)

There are uncertainties in both methods of assessing the effect of scalenotomy In the case records the follow-up varied In the questionnaires, filled in many years after the operation, comparison with the preoperative state must be regarded as uncertain The questionnaires show that the effect did not always last The difference in efficacy of the operation, according to the two methods of arriving at the results, may be caused by a faster recovery in the younger patients

Comparing our results of scalenotomy with other reports is difficult for three reasons most investigations included relatively few patients, there is a varied incidence of cervical osteochondrosis and cervical rib, and different indications for scalenotomy have been used

Rasmussen & Simonsen (1959) reported on 20 patients with "scalenus anticus syndrome", 70 per cent were relieved, 80 per cent had cervical rib and 13 were younger than 30 years Kallio & Rokkanen (1964) described 51 patients Seventy-eight per cent were improved by scalenotomy, 47 were older than 30 and 90 per cent had cervical osteochondrosis Shenkin & Somach (1963) conclude that patients with cervical rib and cervical osteochondrosis / abnormal myelogram are relieved more often than patients *without these signs* We could not confirm this concerning cervical rib

Conclusion

A comparison of our results with other reports does not seem to indicate that diagnostic injection of the muscle is a better criterion for selection for operation than a careful clinical examination

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LATERAL DISLOCATION OF THE ELBOW

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A rare case of a pure lateral dislocation of the elbow joint is presented Attempts at closed reduction were unsuccessful At operation the anconeus muscle was found to be interposed between the articular surfaces of the joint preventing reduction

Key words elbow, *lateral dislocation*, anconeus muscle intrapment, operative treatment

Accepted 6 i 77

Dislocation of the elbow joint is a very common injury, but a variant of this lesion, viz, the pure lateral dislocation of the elbow is extremely rare Linscheid & Wheeler (1965), reviewing 110 cases of elbow dislocation at the Mayo Clinic over a period of 15 years, found only two cases of lateral dislocation In Robert's report (1969) of 60 elbow dislocations there are only two cases of lateral dislocation This specific type of elbow dislocation is also mentioned as being a very uncommon injury by other authors (Smith 1954, Rock & Green 1975)

The rarity of this lesion and the role played by the anconeus muscle in preventing closed reduction in our case justify this report

CASE REPORT

A 35 year-old woman working on a farm fell from a mule onto her left arm and injured her elbow She was admitted to the hospital a few hours later with a very painful swollen and deformed elbow joint The forearm was fixed in pronation and there was a slight varus deformity

Roentgenograms showed a lateral dislocation of the elbow without fracture of the joint (Figure 1) Under general anaesthesia attempts at closed reduction were unsuccessful and therefore open reduction was performed

The elbow joint was exposed using a posterior approach The reduction of the dislocation was prevented by a tight band of the stretched anconeus muscle pressing against and folding the capsule into the dislocated joint This fold of the capsule along with the tight band of the muscle over it was interposed between the lateral condyle and the trochlear notch obstructing the reduction (Figure 2) Reduction was achieved almost spontaneously when the anconeus muscle was dissected from its ulnar insertion

The joint was immobilized in 90° flexion for 3 weeks in a plaster slab After 6 months of physiotherapy a considerable range of elbow movement was regained with flexion extension of 60 to 150° and full pronation supination

DISCUSSION

Pure lateral dislocation of the elbow is very rare (Rock & Green 1975) It is usually the most soft tissue damaging injury of all the varieties of elbow dislocation (Smith 1954) and therefore its closed reduction is an easy procedure

However, difficulties in closed reduction can be encountered and are usually due to avulsion of the medial or lateral condyle of the humerus This becomes in-

DISCUSSION

In patients with pain or paraesthesia in the upper extremity, with tenderness over the anterior scalenus muscle, the diagnosis of "scalenus (anticus) syndrome" was made when no other obvious cause, as for instance cervical disc syndrome, was found (Naffziger & Grant 1938, Judovich et al 1944, Shenkin & Somach 1963). However, Shenkin & Somach (1963) stated that the signs alone were insufficient for the diagnosis At the Orthopaedic Hospital, in Aarhus, we agree with this and have used injection of a local anaesthetic (1 per cent Lidocaine) to relax the muscle and to see whether this would relieve the symptoms In other clinics the physical examination has been supplemented by subclavian arteriography (Somerndike et al 1973) and ulnar nerve trunk conduction studies (Krogness 1973).

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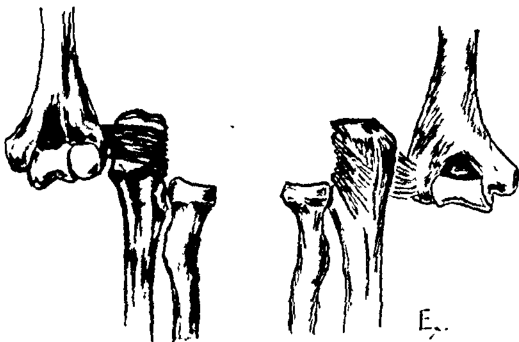


Figure 2 Schematic drawing of the lateral dislocation showing the undamaged anconeus muscle occupying the trochlear notch and obstructing the reduction

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Figure 1 X ray showing the pure lateral dislocation of th ellow joint

serted in the elbow joint preventing the reduction Such avulsed fractures very often accompany this type of injury especially in children (Watson Jones 1957, Wilson 1960, Vijaya 1966)

Soft tissue interposition can also prevent closed reduction of this dislocation as in the case reported by Smith (1954) In his patient the brachialis muscle was found at operation to obstruct the closed reduction, although the capitellum was also avulsed in this particular case

The anconeus muscle is another factor which can prevent reduction of this injury Whenever this muscle remains intact it is stretched and may be displaced into the trochlear notch, obstructing the reduction, as it is then interposed between the lateral humeral condyle and the ulna (Figure 2) This was found in our case and an almost automatic reduction was achieved after the extra articular dissection of the anconeus muscle from its ulnar insertion

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experienced symptoms of ulnar neuritis for periods varying from 14 days to 16 years Fif teen of the patients had suffered for less than 6 months seven for 6 months to 1 year and twelve for more than 1 year The neuritis in 20 patients was located on the dominant side of the body and on the non dominant side in 14 patients

Arthritic changes in the elbow joint were detected in X ray photographs of five patients Calcification just distal to the medial epicondyle of the humerus was found in one patient Six pa tients suffered from acute elbow trauma three from pressure on the nerve during surgery under general anesthesia and in one patient the im pairment began as a result of several days un consciousness in hospital an etiology stressed by Mumenthaler (1961) and Wadsworth & Wil liams (1973) Two patients had chronic elbow trauma and one had slight rheumatoid arthritis of the elbow joint Seventy per cent of the pa tients had earned their living by hard manual labor Patient complaints and objective find ings can be seen in Tables 1 and 2

Table 1 Arm symptoms of 33 patients (34 arms) preoperatively

Impeded work capacity	32
Paresthesia	33
Dyspraxia	21
Reduced strength	18
Pain	9
Cold sensations	6

Table 2 Preoperative objective observations of the arms of 33 patients (34 arms)

Tenderness and paresthesia released from aponeurosis	32
Hypesthesia or dysesthesia	30
Atrophy of hand muscles	17
Paralysis of hand muscles	15
Claw posture	2

Operative procedure

The operation was performed as described by Osborne 1970) An incision exposed the ulnar nerve from the middle of the sulcus to about 6 cm distal to the sulcus The overlying apo neurosis between the two heads of the flexor carpi ulnaris muscle was cut through complete ly The procedure differed from Osborne s in so far as we judged it unnecessary to suture the sectioned ap neurosis profound to the nerve Only the subcutaneous and skin layers were sutured

At surgery no morphological abnormalities were observed in or around the ulnar nerve in 18 patients A structural change in the nerve (a flask shaped bulge) distally limited by the proximal border of the aponeurosis was found in 12 patients Fibrous adhesions around the nerve in the sulcus were seen in four patients No wound complications or clinical deterioration of nerve function were detected in any of the patients

RESULTS

The follow up of 31 patients who had undergone 32 operations was carried out after a period of 7 months to 5 years One of the original patients died and one could not be located but in both cases the first examination indicated pro- nounced improvement The results of the 32 decompression operations appear in Tables 3 and 4

Ninety per cent of the patients had recovered completely or were consider ably improved in their work capacity Sixteen patients reported complete free dom from symptoms of neuritis thirteen patients obtained varying degrees of im- provement and three patients complained of no improvement from the operation During surgery, however no ulnar com pression was observed in these three pa tients, and the ulnar nerves appeared normal but all three suffered from ad ditional neurological diseases, two from cervical disc collapse and one from mas sive post traumatic reflex dystrophy

A second operation was required in two patients One suffered symptom recurrence 6 weeks after primary sur gery and during the second decompres- sion operation a compressing fibrous coat was found surrounding the nerve in the cubital tunnel The patient reported sig nificant improvement 16 months later In the second patient the secondary surgery was anteposition of the ulnar nerve, be cause only slight symptom relief resulted from decompression However during secondary surgery fibrous adhesions in

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COMPRESSION NEURITIS OF THE ULNAR NERVE TREATED WITH SIMPLE DECOMPRESSION

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The purpose of this investigation was to test the hypothesis submitted by Osborne (1957), which proposed that the symptoms of compression ulnar neuritis, in most cases, result from compression on the ulnar nerve at the proximal border of the aponeurosis of the flexor carpi ulnaris muscle Thirty-two simple decompression operations were performed on 31 patients, diagnosed as suffering from compression neuritis of the ulnar nerve They were subsequently examined over a period of 5 years Relief from symptoms was achieved in 28 cases, whilst four patients derived no improvement from the operation Three of the four unsuccessful cases were judged to have been incorrectly diagnosed and were not suffering from compression of the ulnar nerve in the elbow A second operation was required in two patients, in one a second decompression and in the other anteposition No surgical or post-surgical complications occurred

Key words ulnar neuropathy, nerve decompression, compression neuritis, elbow, surgery, operative treatment, long term results

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Osborne in 1957 and Feindel & Stratford in 1958 proposed that the symptoms of ulnar neuritis, in most cases, result from compression of the nerve at the point where it descends below the aponeurosis which is stretched between the two heads of the flexor carpi ulnaris muscle, just distal to the sulcus nervi ulnaris If this supposition is correct, Osborne pointed out that surgical treatment can be reduced to the simple procedure of cutting through the aponeurosis and widening the tunnel in which the ulnar nerve lies

The objective of the work reported in this paper was to test the validity of the supposition and the surgical procedure proposed by Osborne

MATERIAL AND METHODS

The investigation, begun in July 1970 and concluded in March 1975, was made on 33 patients, diagnosed as suffering from compression neuritis of the ulnar nerve The patients were treated by simple decompression surgery at the Department of Orthopedic Surgery, Hjørring Hospital

During this investigation period five additional patients with the same diagnosis were treated by anteposition of the ulnar nerve Two of these patients suffered from pronounced rheumatoid-arthritic changes of the elbow joint one from elbow arthritis with corpus liberum articulare and two from a thickened subluxating nerve These five patients were not included in the results of the investigation

Thirty four decompression operations were carried out on 33 patients one patient being operated on both sides There were 25 men and 8 women 18 to 73 years of age with an average of 48 years Prior to surgery the patients had

position Jensen (1959) based on an observation period of 1¾ years to 9½ years reported that 30 out of 39 patients obtained relief from symptoms six gained slight improvement two were unchanged and one had aggravated symptoms

The results of decompression are also quite similar to those obtained from epicondylectomia medialis humeri Based on a follow up period which ranged from 1 month to 15 years King & Morgan (1959) reported improvement in 18 out of 19 patients Neblett & Ehni (1970) with an observation period of 4 months to 9 years obtained improvement in 13 out of 14 patients

Wadsworth & Williams (1973) employing a combination of anteposition and intra and extraneural lysis observed improvement in only 4 out of 12 patients after an observation time of 6 months to 15 years

Pechan & Julis (1975) proposed that the reason for the more or less similar results obtained from all of the above mentioned methods is due to the fact that the primary tension developing from elbow flexion is exerted from the flexor carpi ulnaris aponeurosis and in addition causes lengthening of the ulnar nerve each contributing about one-half of the directly measured increase in pressure on the ulnar nerve

Jensen (1959) and *Zacharise (1967)* proposed that the degree of surgical success in symptom alleviation is inversely proportional to the preoperative symptom duration in patients This hypothesis was not supported by the results of the present investigation since 8 of the 16 patients who obtained the greatest improvement had preoperative ulnar neuropathy for more than 1 year one for 16 years and three for 5 years

In most cases diagnosis of compression neuritis of the ulnar nerve is not difficult to make and only rarely is a case seen which is complicated and uncertain Simple decompression is an operation which is so free of complications that it can be utilized with great latitude for example as a "diagnostic operation in cases with uncertain diagnosis

The operation is most often successful when the site of maximal tenderness and paresthesia is located at the proximal border of the aponeurosis of the flexor carpi ulnaris muscle Unquestionably, there are cases where anteposition is the most suitable operation particularly when there are pronounced changes in or around the elbow joint

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Table 3 Postoperative improvement in symptoms in the arms of 31 patients (32 arms) related to preoperative complaints

	Preop	Complete recovery	Considerable improvement	Some improvement	No improvement
Impeded work capacity	31	23	5	1	2
Paresthesia	31	16	9	3	3
Dyspraxia	19	12	3	2	2
Reduced strength	16	5	6	1	4
Pain	9	6	0	2	1
Cold sensation	6	4	1	1	0

Table 4 Postoperative objective observations of the arms of 31 patients (32 arms) related to the preoperative condition

	Preop	Complete recovery	Considerable improvement	Some improvement	No improvement
Tenderness and paresthesia released from aponeurosis	31	25	4	2	0
Hypesthesia or dysesthesia	28	14	7	6	1
Atrophy of hand muscles	15	5	2	4	4
Paralysis of hand muscles	12	1	6	4	2
Claw posture	2	0	0	0	2

the sulcus nervi ulnaris were discovered These had not been detected at the first operation The patient reported complete recovery 2½ years later These two patients were included in the results of the investigation, the first patient after and the second patient before the second operation

DISCUSSION

Relief from symptoms by decompression surgery was obtained in 28 of the 32 cases, whilst four patients derived no improvement from the operation In the author's judgment three of these four patients were incorrectly diagnosed, since the symptom picture was masked by other neurological difficulties Decompression surgery for the fourth patient, as far as could be determined, was not performed in a standard manner and anteposition was subsequently performed

The results of these operations correspond quite closely with other decompression investigations Vanderpool et al (1968) reported that 32 out of 36 patients obtained relief from symptoms (observation time not recorded) however, the patients in that study were selected to exclude all long term cases of ulnar neuritis Wilson & Krout (1973) with an observation period of 1 month to 2 years found improvement in 16 out of 16 patients (8 excellent, 4 good, 4 fair) with one patient who required secondary surgery for scar-tissue irritation Feindel & Stratford (1958) reported improvement in three out of three patients with an observation time of 1 to 1½ years

The results from decompression surgery closely resemble those from anteposition surgery For example, Zachariae (1967), in a follow-up after 2 to 10 years reported that 41 out of 46 patients were improved, four were unchanged and one had aggravated symptoms following ante

position Jensen (1959), based on an observation period of 1¾ years to 9½ years reported that 30 out of 39 patients obtained relief from symptoms six gained slight improvement two were unchanged and one had aggravated symptoms

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The operation is most often successful when the site of maximal tenderness and paresthesia is located at the proximal border of the aponeurosis of the flexor carpi ulnaris muscle Unquestionably there are cases where anteposition is the most suitable operation particularly when there are pronounced changes in or around the elbow joint

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OPERATIVE TREATMENT OF ULNAR NERVE NEUROPATHY IN THE ELBOW REGION

A Clinical and Electrophysiological Study

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Thirty-three patients with ulnar nerve neuropathy due to a lesion in the ulnar groove were operated upon during a 5 year period All the patients were analyzed preoperatively One-third of the patients had a history of alcohol abuse Twenty five of the patients were subjected to anterior transposition of the ulnar nerve The results after transposition have been compiled according to etiology, duration age and alcohol abuse All seven patients with only subjective symptoms improved, 11 out of 18 (61 per cent) with motor and/or sensory loss also improved but only six (33 per cent) recovered completely Overall, 21 patients (84 per cent) were improved by the operation In 11 of the transposition cases the ulnar nerve was examined electrophysiologically before and after operation and an improvement of the motor conduction velocity within the elbow segment of the nerve was found in 10 cases

Key words ulnar nerve compression, elbow region, operative treatment, alcohol abuse, electroneurography

Accepted 21 xii 76

The etiology and operative treatment of ulnar nerve neuropathies in the elbow region have been discussed in many papers since the first operation for this lesion was performed by Panas (1878)

The ulnar nerve can be subjected to a primary lesion due to direct trauma or damaged as a consequence of a fracture about the elbow region Neural involvement may occur several years after a fracture due to valgus deformity of the elbow and stretching of the nerve during flexion

The anatomical features around the ulnar nerve may be responsible for compression neuropathy When the ulnar nerve passes from the extensor aspect of the humerus into the forearm in the "cubital tunnel" (Feindel & Stratford 1958) it may be compressed between the fascial band bridging the two heads of the flexor carpi ulnaris and the capsular floor of the ulnar groove The width of the tunnel is reduced in flexion of the elbow Another factor causing narrowing of the cubital tunnel is synovitis with effusion (from osteoarthritis or rheumatoid arthritis) which protrudes into the groove Rarely ganglia and soft tissue tumors may compress the nerve In

some instances recurrent dislocation of the ulnar nerve may cause neuritis Finally a group of patients remains in which none of these etiological factors are represented

Three general categories of operative procedure have been used in the past

1) Anterior transposition of the nerve subcutaneously (McGowan 1950 Goldware & Maxwell 1972) or buried in the flexor mass (Childress 1956 Levy & Apfelberg 1972)
2) Neurolysis i e, breaking up of perineural adhesions (Osborne 1957 Feindel & Stratford 1958 Wilson & Krout 1973)
3) Epicondylectomy (Nicolle & Woolhouse 1965 King & Morgan 1970)

In this paper we present the etiology and clinical findings of 33 cases of ulnar groove syndrome treated over a 5 year period Of these 25 were treated by anterior transposition of the ulnar nerve and were selected for a more intensive postoperative and recuperative study The remaining eight patients received only freeing of the nerve

MATERIAL AND METHODS

At the Orthopedic Clinic of St Goran s Hospital Stockholm 33 patients underwent operation for ulnar groove syndrome during the period April 1969 to April 1974 The patients were referred to the orthopedic clinic from other clinics or from general practitioners There were 11 women and 22 men and their ages varied from 9 to 69 years The mean age was 48 years Nineteen patients were "whitecollar workers" housewives or retired persons Eleven patients were laborers Three were children

All patients were operated on In 25 cases anterior transposition of the nerve was performed while extra epineural decompression was carried out in the remaining eight cases Twenty seven patients were examined with X ray prior to operation

Etiology

As the etiology was obscure to us in many cases and as the majority of the cases in our material cannot be classified as post traumatic we suggest a classification as shown below

A Post trauma neuropathy	12		
Fracture in the elbow region		(11)	Primary neuropathy 8
Dislocation of the elbow		(1)	Late onset of neuropathy 4
B Non traumatic neuropathy	21		
Postoperative	(1)		
Recurrent subluxation of the nerve	(2)		
Rheumatoid arthritis	(4)		
Idiopathic neuropathy	(14)		
Total 33			

A *Post traumatic neuropathy* In this group eight patients had sustained *intra articular* fractures with gross displacement and two patients had small fractures about the proximal part of the ulna Two children with fractures of the shaft of the humerus had been *treated with* olecranon traction

Eight patients who had the onset of their ulnar nerve symptoms at the same time as the accident are classified as primary The late neuropathy group consisting of four patients had all sustained fractures in or *about the el*bow They developed their symptoms 3 months 2 7 and 56 years after the accident

B *Non traumatic neuropathy* In one patient the symptoms appeared after resection of an osteoid osteoma of the olecranon, Neuropathy in this case may have been due to prolonged stretching of the nerve in flexion during the im

[illegible]

[illegible] group no exogenous factor was found explaining the nerve damage and they are *classified as idiopathic*

A history of alcohol abuse (alcohol consumption minimum 1 litre *per week*) was found in 11 patients Eight patients could be referred to the idiopathic group the remaining three belonged to the fracture group

Duration of symptoms prior to operation

In the primary post traumatic neuropathy group the mean duration of symptoms was 18 months ranging from 1 *day to 7 years* In the late post traumatic group the duration of nerve symptoms varied from 4 to 19 months

In the non traumatic group the mean duration

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OPERATIVE TREATMENT OF ULNAR NERVE NEUROPATHY IN THE ELBOW REGION

A Clinical and Electrophysiological Study

HÅKAN LUGNEGÅRD, GERT WALHEIM & ARNE WENNBERG

Hand-Surgery Division of the Department of Orthopaedic Surgery, St Goran's Hospital and Department of Clinical Neurophysiology, Karolinska Hospital, Stockholm, Sweden

Thirty three patients with ulnar nerve neuropathy due to a lesion in the ulnar groove were operated upon during a 5 year period All the patients were analyzed preoperatively One-third of the patients had a history of alcohol abuse Twenty-five of the patients were subjected to anterior transposition of the ulnar nerve The results after transposition have been compiled according to etiology, duration age and alcohol abuse All seven patients with only subjective symptoms improved, 11 out of 18 (61 per cent) with motor and/or sensory loss also improved but only six (33 per cent) recovered completely Overall, 21 patients (84 per cent) were improved by the operation In 11 of the transposition cases the ulnar nerve was examined electrophysiologically before and after operation and an improvement of the motor conduction velocity within the elbow segment of the nerve was found in 10 cases

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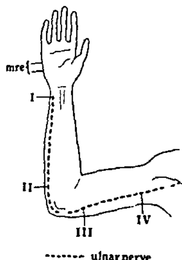


Figure 1 Ulnar nerve Position of stimulation and recording electrodes mre — muscle recording electrodes

IV III 62 7 ± 9 3
III II 37 1 ± 10 3 and
II I 56 1 ± 10 6 m/s

ENeG was done with stimulation of the mixed nerve at the positions I II and III Nerve action potentials were recorded at II (with stimulation at I) and at IV (with stimulation at II and III respectively) At the preoperative examination all patients except one had no visible nerve action potential for the distances I II and II IV In one case a 15 μV potential with the conduction velocity of 49 m s was recorded for the distance II IV In all eight cases a nerve action potential was recorded for the distance III IV Its mean value ± standard deviation was 37 0 ± 23 9 μV the conduction velocity was 59 9 ± 11 0 m s

EMG in the abductor digiti quinti muscle was recorded in nine cases Partial denervation was found in five cases and in one case signs of a lesion of the peripheral motor neurons with reduction of voluntary activity but without signs of denervation was found The other cases had normal EMGs

Operative technique Transposition of the ulnar nerve

In a bloodless field tourniquet pressure 30 50 mmHg above patient s systolic blood pressure and under general anesthesia the ulnar nerve was dissected free from the ulnar groove from the distal part of the upper arm and from the band joining the two heads of the flexor carpi ulnaris This band was always split Care was taken to resect the medial intermuscular septum in the supracondylar region to avoid kinking of the nerve After freeing the first branch to the flexor carpi ulnaris muscle the nerve was re routed anterior to the medial epicondyle Care was taken to secure a straight course for the nerve entering the flexor carpi ulnaris In some instances the muscle had to be split but usually the nerve was located subcutaneously The new course of the nerve was secured by a thin flap of adipose tissue loosely sutured medial to the nerve After release of the tourniquet complete hemostasis was performed A plaster slab was applied from the metacarpophalangeal joints to 10 cm above the elbow keeping the elbow immobilized for 10 days in 80° of flexion After this period the plaster slab and stitches were removed and free movement was encouraged

Operative findings

Local swelling of the nerve was found in two cases of idiopathic neuropathy in one case of rheumatoid arthritis and in two cases after a fracture (3 months or 56 years subsequent to the fracture) In three cases with symptoms occurring shortly after fracture which were promptly operated upon the ulnar nerves were edematous but there were no signs of pressure from bone fragments or any lesion of the nerve No gross changes were seen in the remaining nerves

Complications

There were two cases of hematoma that appeared on the first postoperative day The patients were reoperated and in each case the bleeding vessel was ligated In one of these two patients a partial ulnar nerve paralysis developed and persisted but the patient considered himself as improved

CLINICAL RESULTS

All the patients were re examined at hospital The follow up period ranged from 6 months to 4 years (mean 19 months)

The following factors were considered at the follow up investigation

1) Muscular wasting i e atrophy of the first dorsal interosseous muscle and/or paralysis of the adductor pollicis as demonstrated by Froment s sign
2) Sensibility of the volar aspect of the little finger measured with the 2 PD test

Table 1 Etiology and symptoms in the whole material (33 cases)

Etiology	No of cases	Subjective symptoms			Muscular wasting	Signs			Only subjective symptoms
						2 PD			
		Numbness	Pain	Coldness		No	7–15 mm	< 7 mm	
EFL primary	8	7	3	2	5	5	2	0	1
EFL late	4	4	4	1	1	1	0	3	3
Postoperative	1	1	1	0	0	0	1	0	0
RLU	2	0	2	0	0	0	0	2	2
RA	4	4	4	1	0	1	2	1	1
Idiopathic	14	14	8	3	12	8	4	2	1
Total	33	30	22	7	18	15	9	8	8
Alcohol abuser	11	11	6	4	8	6	3	2	2

EFL = Elbow fracture or luxation RLU = Recurrent luxation of the ulnar nerve
RA = Rheumatoid arthritis

of symptoms was 11 months ranging from 1 month to 24 months

The alcohol abuse group presented a mean duration of symptoms of 17 months

Clinical features

All the patients were right handed The neuropathy was confined to the right arm in 16 of the 33 cases and in the idiopathic group in five cases out of 14

Symptoms The dominant subjective symptoms were numbness and tingling in the little finger and the ulnar half of the ring finger and weakness of grip These symptoms were present in all cases except three Pain along the ulnar nerve in the forearm and hand was a dominant complaint in 22 cases Seven patients had a sensation of coldness in the ulnar fingers Eight patients had only subjective symptoms (Table 1)

Signs All patients demonstrated a positive Hoffmann Tinel s sign distal to the ulnar groove indicating the level of the nerve injury At clinical examination 18 patients demonstrated atrophy of the first interosseous muscle and the same 18 patients had positive Froment s sign (i e pronounced flexion of the interphalangeal joint of the thumb when pinching with the index finger) No patient had motor impairment exclusively

The sensibility was measured on the volar aspect of the fifth fingertip with the two point discrimination test (2 PD) Fifteen patients had complete loss of 2 PD nine patients had impaired 2 PD (7–15 mm) and eight patients had normal or close to normal 2 PD (below 7 mm) In one patient sensibility could not be tested because of a previous finger amputation

In the primary post traumatic neuropathy group seven out of eight patients demonstrated signs of motor and/or sensory dysfunction In the late post traumatic group three patients out of four had only subjective symptoms Among the 14 patients in the idiopathic group there was only one patient with solely subjective symptoms

Electrophysiological examinations

Estimation of motor nerve conduction velocity (MCV) was performed on 13 of the patients of which 11 belonged to the transposition group (four from the post traumatic and seven from the non traumatic group) Only the results from these 11 patients will be discussed here

Out of these 11 patients electroneurography (ENeg) was performed in eight cases The MCV and ENeG examinations were done using the usual technique (Dawson & Scott 1949 Gilliatt & Sears 1958 Buchthal & Rosenfalck 1966 Wennberg & Widén 1966) Electrode positions E I-V are shown in Figure 1 Electrical stimulation for the MCV estimation was always done with a unipolar needle electrode and the nerve action potentials were recorded with the same needle (an unisolated 0 2 mm tungsten electrode electrolytically polished to a tip diameter of 5 15 μm inserted through the skin) To insert the needle as close as possible to the nerve a standardized procedure was used with the recording needle as stimulating cathode (Buchthal & Rosenfalck 1966) The preoperatively recorded MCV values of the 11 cases (mean ± standard deviation) for the different inter electrode distances (cf Figure 1) were

Table 4 Improvement factor after transposition related to age (n = 25)

Symptoms/signs	No	Motor function improved	Sensibility improved	Only subjective symptoms improved
< 50 years	12	4/5 (80 %)	5/7 (70 %)	5/5 (100 %)
> 50 years	13	2/7 (29 %)	6/11 (55 %)	2/2 (100 %)

Table 5 Improvement factor after transposition related to alcohol abuse (n = 25)

Symptoms/signs	No	Motor function improved	Sensibility improved	Only subjective symptoms improved
Alcohol abuse	6	1/4 (25 %)	1/5 (20 %)	1/1 (100 %)
No alcohol abuse	19	5/8 (63 %)	10/13 (77 %)	6/6 (100 %)

postoperatively Five patients with exclusively subjective symptoms all improved Corresponding figures in the older group were motor improvement in two out of seven cases and sensory improvement in six out of eleven cases Both patients with only subjective symptoms improved (Table 4)

B *Severity and duration of symptoms*
Eighteen patients had motor and/or sensory loss preoperatively Only six patients with a duration of symptoms of 7 months, recovered completely The other 12 improved only partially or not at all The mean duration of symptoms in this group was 14 months Seven patients with only subjective but typical symptoms all improved The mean duration of symptoms in this group was 24 months

C *Alcohol abuse*
Six patients with alcohol abuse were compared to the remaining 19 patients Only one out of four patients with muscular wasting and one out of five with sensory loss improved in the former group (duration of symptoms 19 months) In the non-alcoholic group the corresponding figures were five out of eight for motor improvement and 10 out of 13 for sensory improvement (Table 5)

ELECTROPHYSIOLOGICAL RESULTS

Postoperative electrophysiological examination was performed between 6 months and 2 years after the operation except in one case, which was examined after 1 month In all cases an increase of the MCV could be demonstrated for the distance III II (cf Figure 1), which is the elbow region of the nerve The MCV mean value ± standard deviation for this distance was postoperatively 47 7 ± 6 8 m/s, which is a highly significant ($P < 0.005$) increase from the preoperative value 37 1 ± 10 3 m/s Postoperative MCV values for the other distances were IV–III 57 1 ± 4 1 and II I 53 4 ± 8 2 m/s These values are not significantly changed in comparison with the preoperative values The postoperatively recorded nerve action potential was for the distance III–IV 37 8 ± 33 6 μV with conduction velocity 63 6 ± 6 0 m/s which does not significantly differ from the preoperative values In two cases it was possible to record nerve action potentials for the distances I II and II–IV, where no measurable action potential could be recorded preoperatively It was in both cases less than 20 μV

Thus, in this material MCV in the nerve segment III–II was the only electrophysiological variable that was signif-

Table 2 Results after transposition of the ulnar nerve (n = 25)

Symptoms/signs	No	Improved motor+sensory	Improved only sensory	Improved only subjective	Not improved
Motor and sensory loss	12	6 (4)*	1	2	3
Only sensory loss	6		4 (2)*	1	1
Only subjective	7			7	
Total	25	6 (4)*	5 (2)*	10	4

* In brackets, complete recovery

3) The patient's own evaluation with respect to pain, numbness tingling and weakness

Improvement of muscular function was defined as disappearance of Froment's sign and/or reappearance of palpable contractions of the first dorsal interosseous muscle Improvement of sensibility was defined as improved 2 PD, e g, change from no 2 PD to 15 mm or a measurable improvement exceeding 3 mm

Out of 12 patients with combined motor and sensory loss, six patients improved in both respects, but only four patients recovered completely (two posttraumatic neuropathies operated on soon after fracture, one with rheumatoid arthritis with a duration of nerve symptoms of 70 days and one with idiopathic neuropathy for 12 months) In one patient only the sensibility improved The *remaining* five improved only subjectively or not at all

Four out of six patients with only sensory loss improved as measured with the 2 PD test two of these regained normal 2 PD The only patient made worse had normal motor function preoperatively and demonstrated weakness of the first interosseous muscle at follow-up (post-hematoma)

Twenty-one patients (84 per cent) improved, three patients with objective symptoms improved only subjectively All seven patients with only subjective symptoms improved (Table 2)

The results divided according to etiology are given in Table 3

Table 3 Results after transposition divided according to etiology (n = 25)

Etiology	Improved	Not improved
Posttraumatic primary palsy	6	1
Late palsy	3	1
Recurrent luxation of nerve	2	
Rheumatoid arthritis	4	
Postoperative	1	
Idiopathic	5	2
Total	21	4

PROGNOSIS OF ULNAR NERVE TRANSPOSITION

In an attempt to forecast the outcome of ulnar nerve *transposition the importance* of the patient's age, the severity and duration of the symptoms, and the influence of alcohol abuse were investigated

A *Patient's age*

Twelve patients younger than 50 years were compared to 13 patients older than 50 years In the younger group four out of five of the patients with with motor loss and five out of seven with impaired sensibility improved

athy may make the nerve more vulner able

There seemed to be a difference between the younger age group and those patients older than 50 in favor of the younger group However, the difference is not statistically significant In agreement with Harrison & Nurick (1970) we found that the duration of preoperative symptoms seemed to influence the outcome but only in cases with clinically evident motor and/or sensory loss The prognosis in cases with only subjective symptoms was uniformly good in this material irrespective of the duration of the preoperative symptoms This group may be compared to McGowan s grade 1 "Minimal lesions with no detectible motor weakness of the hand Most reports of the results after transposition of the ulnar nerve have been enthusiastic Thus, McGowan reports 75 100 per cent success even in cases of "tardy palsy in a group consisting of 46 patients Gay & Love (1947) found satisfactory results in 80 per cent of 100 patients but the majority were followed up by questionnaire and no data apart from the patients opinions are given

The results reported by Sunderland (1968) give another picture Out of 14 patients only six improved (two patients were cured) and four patients were considered even worse after transposition

In the present series 11 out of 18 patients (61 per cent) with motor and sensory loss improved but only six (33 per cent) recovered completely The duration of symptoms of these six was half as long as in the group of 12 patients with partial or no recovery Based on this series an early operation seems to give the best result

The electrophysiological examinations showed improvement of motor nerve conduction velocity even in those cases where clinical improvement could not be recorded This indicates that at least some of the electrophysiological examinations are more sensitive than the clinical ones as in other types of neuropathies (Downie & Newell 1961, Lockner et al 1969, Lofstrom et al 1966) Our results are in good agreement with those presented by Payan (1970) of 13 patients with lesions of the ulnar nerve at the elbow

Electromyography was, however, found to be a quite insensitive test of nerve recovery in this series

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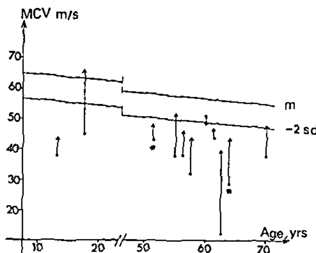


Figure 2 MCV in nerve section III–II (cf Figure 1) Every case is plotted as a vertical line, in which the dot marks the preoperative value and the arrow the postoperative value The oblique lines denote mean values and −2 standard deviations in a material of healthy volunteers (from Knave et al 1974) The two cases which were not improved clinically after the operation are marked with asterisks

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The extent of electrophysiological improvement was not correlated to the age of the patient, the duration of symptoms, the genesis of the lesion, the severity of clinical symptoms or whether or not the patient had a history of alcohol abuse

Postoperative EMG examination was performed in only six out of nine preoperatively examined cases Two were slightly improved, the others were unchanged

DISCUSSION

In classifying ulnar nerve neuropathies, in which the continuity of the nerve is not lost, one usually makes a division of the lesions into

A Primary and secondary neuropathy resulting from trauma
B Late neuropathy resulting from old fracture, arthritis, congenital anomalies, etc

In this material the group of late or *tardy neuropathies* consists of four cases —an astonishingly low figure in comparison with other consecutive series These four patients had sustained fractures about the elbow 3 months, 2, 8 and 56 years prior to the neuropathy and only the patient with an interval of 56 years presented a cubitus valgus, thus fulfilling the criterion of the most common etiology of "tardy ulnar palsy" according to the classical observations of Broca & Mouchet (1899) and of Platt (1925)

Fourteen patients had no known previous injury to the elbow region The etiology remains obscure to us in these cases and we could only find two cases of thickened nerve and no case of obvious compression of the nerve in this group

A striking feature in this material not stressed in earlier reports, is the relatively large group, 11 cases (33 per cent), with a history of alcohol abuse The results after transposition in this group are inferior to the results in the non alcoholic group It is probable that the ulnar nerve in alcohol abusers is more frequently subjected to small injuries or to compression and/or prolonged stretching with the elbow in flexion during sleep

This pathogenesis has been suggested by Mumenthaler (1961), who accounts for 44 cases of ulnar neuropathy after states of prolonged unconsciousness and by Engkvist (1972), who found 12 ulnar palsies consequent to surgical operations under general anesthesia Two of the alcohol abusers in this material also had diminished sensibility within the median nerve area in both hands, indicating polyneuritis, and it should be considered that even a subclinical alcohol neurop-

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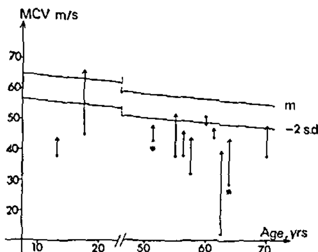


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PREVALENCE OF ADOLESCENT IDIOPATHIC SCOLIOSIS IN HUNGARY

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The prevalence of AIS was studied by examining 22,624 microfilms and obtaining additional clinical and radiological information in 201 out of 223 selected cases In our material the total prevalence of scoliosis was 8 8-9 7 per thousand, whereas the prevalence of AIS was 5 1-5 4 Considering only AIS over 10° the prevalence was 2 91 per thousand

Key words idiopathic scoliosis, prevalence

Accepted 2 1 77

According to the age at onset, the sex, the type and location of the curve and the prognosis three groups of idiopathic scoliosis (i) infantile, (ii) juvenile and (iii) adolescent can be distinguished (Beals 1973, James 1973, Mau 1972, Wynne-Davies 1968, 1975) Our study gives an account of the prevalence of adolescent idiopathic scoliosis (AIS) in Hungary

MATERIALS AND METHODS

When surveying the prevalence of scoliosis at least five methodological aspects have to be taken into account

1 *Definition of AIS* AIS can be defined as a stable more or less fixed, progressive curve of the spine accompanied by a rotation around the vertical axis of the vertebrae and a torsion in the horizontal plane occurring between the ages of 10 and 14 predominantly (90 per cent) on the right side and mostly in girls

2 *Age* As AIS generally appears at 10-14 years of age only those over 14 years were examined

3 *Definition of the sample* A series of fluorograms (microfilms) taken during routine X ray screening were used (i) The examinations were obligatory, therefore, the requirement of completeness was fulfilled appropriately, (ii) The X-ray screening did not entail any selection for scoliosis, (iii) Microfilm seemed to be adequate for diagnosing scoliosis

4 *Number of elements in the sample* Taking into consideration the prevalence of scoliosis reported in the literature 2-6 per thousand (Table 1), about 20 000 was set as the number of elements so that 2 S D falls below 20 per cent.

5 *Method of examination* After a screening based on microfilms, an exact diagnosis using full size radiography was made in each of the selected cases

In 1974-75 22 624 microfilms from a definite geographical and administrative area (Dombóvár district) were examined They had been taken in 1971 as part of the continual X ray screening which has been carried out for those over the age of 14 in Hungary, since 1961 So not less than four, but in some cases 14 microfilms, could be examined in 11,450 females and 11 174 males Comparing the microfilms of good quality showing the upper part of the lumbal spine we were able to eliminate several technical mistakes and in many cases to recognize the progress of scoliosis

The examination was carried out in several stages (i) The phthisiologist selected cases with the slightest signs of scoliosis or any other defects

Table 1 The prevalence of adolescent idiopathic scoliosis

Authors	Year	Country	Definition	Age	Sample
Shands & Eisberg	1955	USA	AIS	14	representative
Lettow	1965	Democratic Republic of Germany	IS	0–18	representative
Wynne Davies	1968	Scotland	AIS	10–18	representative
Kane & Moe	1970	USA	AIS	14	hospital
Filho & Thompson	1971	Canada	AIS	?	hospital
Our material	1975	Hungary	AIS	14	representative

(ii) The microfilms of 413 selected cases were looked through by two orthopaedists independently (in order to eliminate subjectivity) and in 223 cases a distinctly visible curve was found on each microfilm

(iii) These 223 scoliotic patients were requested to come for radiologic and genetic examinations during the spring of 1975 A total of 204 patients responded (91 per cent), 5 of them had died, and 14 did not appear even after repeated requests

(iv) A detailed case history was obtained and a clinical examination made A full size X-ray exposure of the spine in the standing position was taken for each of the 204 patients The angle of curvature was determined according to Cobb s method (Neugebauer 1972)

RESULTS AND DISCUSSION

In three of the 204 patients who came for the examination, scoliosis was not found Thus, based on 201 cases the total prevalence value for scoliosis, in the population of 22,624 individuals over 14 years of age, was 8 8 ± 0 6 per thousand This figure includes all types of scoliosis *AIS* occurred in 116 cases, so its prevalence is 5 1 ± 0 5 per thousand The frequency of the so-called clinical cases (over 10°) was only 2 91 ± 0 35 per thousand (66 cases) These values can only be considered as minimal prevalences since 19 patients were not examined With only the microfilms available in these cases a diagnosis with a 98 7 per cent level of accuracy could be made, thus 8 of the 19 cases could be regarded as AIS, and 11 as other types of scoliosis *In this way the real prevalence of AIS* is 5 4 ± 0 5 per thousand, whereas the total prevalence of scoliosis is 9 7 ± 0 6 per thousand

It is important from the point of view of evaluating the prevalence values in our survey that curves between 5–10° were also involved In earlier definitions of occurrence, in nearly all cases only curves over 10° have been taken into account We did not adhere to this for three reasons (i) The milder cases are also needed for further genetic survey (ii) The microfilm plus clinical and X ray examinations formed a reliable basis for the diagnosis of mild as well as more severe cases (iii) In judging the progression, knowledge of the initial angle is of great importance

The prevalence of AIS in our country and in Europe, as well as in North

AIS) or idiopathic scoliosis (IS) in different countries

Number of sample	Method	Number of patients	Prevalence per 1000 persons	Sex ratio
15 000	microfilm + X ray in selected cases	61	4 0	0 2857
81,243	clinical examination	?	6 4	–
7,894	clinical examination + X ray in selected cases	17	2 2	0 1429
75 ?30	X ray	100	1 3	0 2000
?	X ray	413	1 8	0 1000
22 624	microfilm + clinical examination + X ray in selected cases	66 (above 10°) 116 (all cases)	2 9 5 1–5 4	0 2941 0 4762

Table 2 Type of scoliosis and severity of the curve in 201 scoliotic patients (f=females m=males)

	5–10°		11–20°		21–30°		31–50°		51–75°		over 76°		Total		Grand total	
	f	m	f	m	f	m	f	m	f	m	f	m	f	m	No	Per cent
Idiopathic	28	22	24	7	8	3	13	3	2	2	4	0	79	37	116	57 6
Congenital	2	6	8	12	1	2	–	–	–	–	1	4	12	24	36	17 6
Sprengel	1	1	5	–	–		–	–	–	–	–		6	1	7	3 5
Scheuermann	5	3	–	3	1	–	–		–	–	–	–	6	6	12	6 0
Osteoporosis	3	2	2	3	–			–	–		–		5	5	10	5 0
Rickets	–	1	–	–	1				–	–	2	–	3	1	4	2 0
Statical	3	5	1	1		–			–		–		4	6	10	5 0
Poliomyelitis	–		–			1		–	–		1		1	1	2	1 0
Recklinghausen	1	–	–			–		–		–			1	–	1	0.5
Bechterew	–	1	–	–	–		–		–	–	–	–		1	1	0 5
Cerebral palsy	–	–	–	1	–		–		–		–		–	1	1	0 5
Spondylitis tuberculosis					1			–	–	–		–	1	–	1	0 5
Total	43	41	40	27	12	6	13	3	2	2	8	4	118	83	201	100 0

America (only data from these continents are at present available) is almost the same (Table 1)

The type of scoliosis and the severity of the curve was determined by clinical and radiological examination in the 201 scoliotic patients (Table 2) They were divided into six groups according to the angle of the curve (as given by Cobb) (Table 2) Among curves over 30° only AIS (24 cases), congenital scoliosis (5 cases), scoliosis caused by rickets (2 cases) and paralytic scoliosis (1 case) were represented

In the population examined there were slightly more females than males, ratio 1 1 02 Among the 201 cases of scoliosis the proportion of females was somewhat,

though not significantly, higher (1 1 4) In AIS, however, the female predominance became marked (1 2 1) and it increased proportionally with the severity of the curve (over 10°, the male female ratio was 1 3 4)

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BLADDER FUNCTION AFTER HEMIPELVECTOMY

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Bladder function was studied in seven patients 5 to 90 months after hemipelvectomy. The urological investigation comprised i.v. urography, micturition-cysto-urethrography, cystoscopy, cystometry and urodynamic investigations in terms of simultaneous flow and pressure measurements. Hemipelvectomy was found not to give rise to disturbances in micturition.

Key words: hemipelvectomy; urodynamics; pressure, flow, urination; neurogenic bladder.

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Hemipelvectomy is performed where amputation is required because of malignant tumours in the pelvis or the upper femur. This extensive operation causes a variable, unilateral damage to the innervation of the urinary bladder.

Normal bladder function is dependent on an intact nervous system, consisting of autonomic, somatic and sensory pathways. The innervation of the detrusor is mainly parasympathetic, while the function of the sympathetic innervation of the trigone is still disputed. The parasympathetic nerves run from the sacral medulla segments II-IV (S_{II}-S_{IV}), to the pelvic plexus at the level of the lateral wall of the rectum, where they branch to the ureterovesical region. The sensory innervation of the bladder comprises proprioception (stretch) and exteroception (pain), proprioception being by far the more important, as it is responsible for the micturition reflex and the sensation of bladder dilation. Some of these fibres follow the sympathetic hypogastric nerve to the sympathetic trunk and the thoracolumbar medulla. The pelvic floor including the external sphincter receives somatic innervation from the pudendal nerve, which in addition is responsible for the sensory innervation of the urethra distal to the prostate. There is supposed to be unilateral innervation of the detrusor muscle and a complementary function of the three segments in the sacral medulla, with S_{III} as the most important. The sacral cord segments II-IV are the simple reflex arcs of the visceral and the somatic nerves, which are influenced by inhibitory and facilitative pathways from the medulla, cerebellum and cortex (Bors & Comarr 1971). In our patients, hemipelvectomy involves transection of the pudendal nerve, and in addition a risk of damage to the parasympathetic and sympathetic nerve supplies to the bladder at the periphery, where the nerve fibres are running in the pelvic and vesical plexus. We therefore consider it of some interest to examine the

though not significantly, higher (1 1 4) In AIS, however, the female predominance became marked (1 2 1) and it increased proportionally with the severity of the curve (over 10°, the male female ratio was 1 3 4)

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Table 3 Cystometry and simultaneous pressure and flow measurements in 7 patients 5-90 months after hemipelvectomy

Patient no	Cystometry	Simultaneous pressure and flow measurements				
		Micturition volume ml	Intravesical pressure prior to micturition mmHg*	Micturition pressure at maximum flow mmHg	Max flow ml/s	Detrusor function
1	normal	200	20	60	10	+
2	normal	450	15	60	21	+
3	normal	400	35	60	16	+
4	normal	480	30	100	24	+
5	normal	300	30	100	8	+
6	normal	200	not performed	22	15	+
7	normal	750	20	55	36	+

* 1 mmHg pressure = 1.36 cm H_2O pressure

Table 4 X ray investigation and cystoscopy

Patient no	MCU	Reflux	Urography	Cystoscopy
1	normal	—	asymmetric bladder	not performed
2	normal	—	asymmetric bladder	normal
3	normal	—	normal	normal
4	normal	—	normal	cystitis
5	narrow posterior urethra	—	prostate impression in the bladder base	posterior urethritis prostate hypertrophy
6	normal	—	normal	normal
7	normal	—	normal	normal

Urological follow-up examination comprised microscopy and bacteriological examination of urine serum creatinine determination i v urography micturition cysto urethrography (MCU) cystometry and urodynamic investigation (pressure flow study) MCU was performed in lateral projection in all patients three films being made one before one during and one after micturition Bladder configuration was evaluated from a bladder filling picture in i v urography and from cystoscopy

The urodynamic studies were performed as described by Iversen Hansen (1973) and the parameters measured are indicated in Tables 2 and 3 The patients were asked to attend the examination with a full bladder and a spontaneous micturition curve was recorded using a flowmeter A thin catheter was inserted into the bladder by the transurethral route and the residual urine was measured. A thin catheter was also inserted into the rectum and pressures were recorded in both the bladder and the rectum Successive pressure estimations were made after each instillation of 50 ml saline in the bladder both "first sensation" and "definite sensation of fullness" (cystometric capacity) being recorded. The final pressure-flow study was performed after the bladder was filled through the transurethral catheter, pressures and flow being recorded simultaneously during micturition

RESULTS

Table 2 shows the results of the examination of spontaneous micturition All patients had maximum flow within the normal range This was also the case in patients Nos 2 and 5, who on examination

Table 1 Age and sex, tumour diagnosis and time of urological follow-up in 7 patients submitted to hemipelvectomy

Patient no	Age	Sex	Tumour diagnosis	Type of operation*	Urological follow up in months post operation
1	13	M	osteogenic sarcoma of the femur	A	10
2	17	M	osteogenic sarcoma of the pelvis	A	5
3	26	M	osteogenic sarcoma of the femur	A	72
4	29	M	osteogenic sarcoma of the pelvis	A	31
5	41	M	neurofibrosarcoma of the pelvis	B	90
6	25	F	chondrosarcoma of the pelvis	A	31
7	54	F	osteogenic sarcoma of the femur	B	44

* c f text operative procedure

Table 2 Spontaneous micturition in 7 patients 5 to 90 months after hemipelvectomy

Patient no	Maximal flow ml/s (micturition vol ml)	Residual volume (ml)	Urinary culture
1	21 (320)	0	sterile
2	22 (100)	0	sterile
3	19 (200)	0	sterile
4	24 (260)	50	sterile
5	17 (120)	0	sterile
6	21 (330)	90	sterile
7	35 (400)	0	sterile

bladder function in a number of patients who have undergone hemipelvectomy

MATERIAL AND METHODS

Patients The material consists of the seven surviving patients out of 23 patients who underwent hemipelvectomy in the Department of Orthopaedic Surgery at the University Hospital during the period 1964–1972 Table 1 shows age, sex and preoperative tumour diagnosis None of the patients had any urological symptoms before operation All patients were hospitalized for follow-up examination The period from hemipelvectomy to urological follow up examination varied from 5–90 months (Table 1)

Operative technique in hemipelvectomy Hemipelvectomy was performed as described by previous authors (Gordon-Tayler & Monro 1952 Bertelsen & Meyer 1961, Ravitch & Wilson 1964, Den Otter 1972) Anteriorly, the pelvis was divided near or in the symphysis and posteriorly through the greater sciatic notch and up over the iliac crest, more or less close to the sacro iliac joint The iliac vessels were exposed anteriorly together with the ilio-psoas muscle The femoral nerve and obturator nerve were transected from the inside of the pelvis, while posteriorly the sciatic nerve was transected where it emerges from the pelvic cavity through the foramen infrapiriformis The pudendal nerve was transected together with the sacro-tuberous ligament and the sacro spinous ligament After dividing the pelvic wall, the bladder and rectum were exposed medially, employing blunt dissection in the paravesical and pararectal connective tissue space During this dissection the pelvic plexus (i e the inferior hypogastric plexus) and the vesical plexus are in danger of damage In five patients the hemipelvectomy was performed by transection of the pelvis anteriorly in the symphysis and posteriorly immediately lateral to the sacro-iliac joint (type A Table 1) A slightly less radical intervention was carried out in two patients the resection line anteriorly in the bone lying 2 cm lateral to the symphysis and posteriorly from the greater sciatic notch to midway between the superior and inferior anterior iliac spine (type B, Table 1)

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had micturition volumes less than the value usually required for evaluation of maximum flow.

Cystometry (Table 3) showed in all cases normal pressure during filling without uninhibited contractions or low pressure filling curve, i.e. without signs of neurogenic bladder dysfunction. Simultaneous pressure flow measurement showed normal premicturition pressure in all patients except No. 6, whose pressure was not measured because of a fault in the apparatus. Micturition pressure at maximum flow was found to be elevated in two cases (patients Nos. 4 and 5, Table 3). Patient No. 4 showed pronounced inflammatory changes in the bladder on cystoscopy, which might explain the elevated micturition pressure. In patient No. 5, the elevated micturition pressure together with the low flow and the elevated residual urine suggest infravesical obstruction. Infravesical obstruction not caused by hemipelvectomy was confirmed by MCU, i.v. urography and cystoscopy (Table 4). In patient No. 7 both spontaneous micturition examination (Table 2) and determination of simultaneous pressure and flow (Table 3) showed a large micturition volume 750 ml on last investigation. The other parameters in this patient were found to be normal. An MCU investigation could show no reflux in any of the patients (Table 4). In two cases urography showed that the bladder was asymmetrical (patients Nos. 1 and 2, Table 4). Cystometry and urodynamic investigation showed no signs of denervation of the bladder in these patients.

DISCUSSION

Following major operations in the true pelvis, e.g., extirpation of the rectum and radical hysterectomy, disturbances of micturition may often arise as a result of damage to the innervation of the bladder (Baumrucker & Shaw 1953, Bowers et al. 1957, Bors & Comarr 1971, Tank et al. 1972, Ward & Nay 1972, Roman Lopez & Barclay 1973, Held 1974, Kontturi et al. 1974, Barclay & Roman Lopez 1975, Lickenberg et al. 1976). In these types of operation it may be assumed that there has been bilateral damage to the pelvic plexus resulting in infranuclear bladder paresis. In hemipelvectomy, damage to the nerve supply to the bladder is strictly unilateral, but presumably involves both the pelvic plexus and the pudendal nerve. As the present follow-up investigation shows, unilateral denervation of the bladder does not result in neurogenic bladder dysfunction. The result of our investigation is in accordance with animal investigations and with human investigations involving procedures other than hemipelvectomy. Kimmel (1966) has reported that in rats only one pelvic nerve is necessary to maintain good bladder function. Ericsson et al. (1970) found normal bladder function in patients with myelomeningocele causing unilateral neurological defects. Gunterberg et al. (1975) showed that resection of the sacrum with unilateral lesion of sacral nerves 1 to 5 did not abolish the micturition reflex. It is possible that by employing electrical stimulation of the detrusor muscle, electromyography or a denervation hypersensitivity test with carbacholine the presence of unilateral denervation could have been demonstrated in the present investigation.

It may be concluded from the present investigation that hemipelvectomy with possible unilateral denervation of the bladder does not give rise to clinically or urodynamically recognisable disturbances in micturition.

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Clinical examination of newborn babies was performed in the nursery between the second and sixth day of age. A follow-up study of these babies was made in pediatric and orthopedic clinics. The clinical examination consisted of observation and manual examination of the hips. The diagnosis was confirmed in every case by radiography. In this study all babies exhibiting hip pathology were born in the occiput presentation. It is also important to emphasize that in all the cases there were no associated congenital deformities. The treated infants have been followed for an average of 20 months. During this period we have carried out clinical and laboratory studies on all the mothers of these infants because of an unexpected observation: all mothers of the infants with LAH were suffering from thyroid disorders. All these mothers have been examined and given thyroid tests.

In order to be also able to evaluate the maternal thyroid disorders in association with neonatal hip pathology, muscle specimens taken from the affected hips of all 10 infants were studied histologically. Some specimens of shoulder muscles taken from the same infants were used as control specimens. The criterion for dividing the mothers into two series was the clinical form of congenital hip pathology in the infants. Two clinical forms were clearly distinguished. These were: (a) LAH and (b) AD. In the same way, a second unselected criterion arose, viz., the family history. It is of some interest that accurate family history has been obtained with negative results for the first group in contrast to the second where a positive family history has been observed for all cases. This point has been systematically studied. Thus the first series consisted of 10 mothers who had children with LAH and a negative family history for this condition. The second series concerned 9 mothers whose infants were afflicted with AD. In this series all cases showed a positive family history of hip disorder. All mothers came from the same geographic area. The age distributions in both series were approximately the same.

FINDINGS

Group I

A. *Mothers who had infants with LAH and a negative family history.* The thyroid gland was enlarged in every mother. Tests of thyroid function revealed the following:

1. Out of six women with clinically suspected thyroid hyperfunction, three had hyperthyroidism caused by a hyperfunctioning adenoma, one had Graves' disease and two had undergone thyroid operations for toxic goiter. Three of the latter had had a poor outcome of previous pregnancies.
2. Autonomous thyroid nodule was diagnosed in two mothers.
3. In one mother the thyroid gland was multinodular and biopsy examination revealed changes of papillary adenocarcinoma in some areas.
4. One mother had euthyroid goiter.

B. *Affected infants.* Ten infants with clinical signs of LAH to 45° at birth were not treated for 3 months to see what would happen. The first infant developed hip dislocation at 3 months of age. The child was then treated with traction, closed reduction and hip spica. Four babies developed hip subluxations at 1½ months of age and were treated with Frejka pillows for a period of 5 months. The other five were checked at 3 months of age. Paradoxically, the author had an unpleasant surprise. After this period the hips were abnormal clinically and X-ray showed epiphyseal dysplasia bilaterally. These hips were severely affected. The epiphyseal nuclei were completely destroyed whereas the acetabulae were well formed. In this group, early appearance of the upper femoral epiphysis was a common feature. The time of appearance of the ossification center ranged from 3 to 6 weeks. In no case was there any family history of hip disorder.

Histological examination. The morphology (using light microscopy) of muscle specimens from the 10 infants suffering from LAH was studied. The specimens were from the pelvifemoral, the pelvitrochanteric, and the gluteal groups. A total of 30 specimens (one from each

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LIMITATION OF ABDUCTION OF HIPS IN THE NEWBORN

Is It A Clinical Sign or a Phenocopy of Congenital Hip Dislocation?

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Until recently the possibility of a connection between maternal thyroid disorders and congenital hip pathology in the newborn has not been given any attention However, from this study it is evident that there is a close relationship between maternal thyroid disorders and limitation of abduction of the hips in the newborn The histological findings are suggestive of a neonatal thyrotoxic myopathy or periodic paralysis which might give rise to an error in muscle balance around the hips The high proportion of affected children without a family history of congenital hip dislocation suggests that genetic factors have in the past been overemphasized

Key words limited hip abduction, phenocopy, thyrotoxic myopathy

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Congenital hip dislocation (CDH) is an important abnormality partly because it is so frequent In recent years many studies have attempted to demonstrate the etiology of this common deformity The genetics of CDH is considered complex At the present time, the inclination is to accept multifactorial inheritance for this defect, as has been done by several geneticists However, the causation of CDH is thoroughly confused and many questions remain unanswered In the present study, attention has been focused on the possible relationship between maternal thyroid disorders and neonatal hip pathology Work in this field has been stimulated by the incidence of thyroid disorders in mothers whose newborn babies had limitation of abduction of the hips (LAH) A muscular histopathology tending to be more obscure in infants with LAH was first described by Matsoukas et al in 1969 The author has made an effort to classify these abnormalities and to introduce them as a factor in the pathology of LAH It might be noted that in Greece, a complete overlapping between areas of CDH and regions of thyroidopathies is observed It seems to be true that the same phenomenon is found worldwide

MATERIAL AND METHOD

During the period 1967 to 1975 the hips of 2000 newborn babies were examined Among the 2000 newborns congenital hip pathology was detected in 19 babies (15 female, 4 male) This material was classified into two groups (a) Ten female infants with LAH One of them had unilateral CDH four developed bilateral hip subluxation and five exhibited severe epiphyseal dysplasia bilaterally without subluxation or dislocation (b) Nine infants (5 female 4 male) with acetabular dysplasia (AD) with hips dislocated or 'good hip' at risk

Clinical examination of newborn babies was performed in the nursery between the second and sixth day of age A follow up study of these babies was made in pediatric and ortho pedic clinics The clinical examination con sisted of observation and manual examination of the hips The diagnosis was confirmed in every case by radiography In this study all babies exhibiting hip pathology were born in the occiput presentation It is also important to emphasize that in all the cases there were no associated congenital deformities The treated infants have been followed for an average of 20 months During this period we have carried out clinical and laboratory studies on all the mothers of these infants because of an un expected observation all mothers of the infants with LAH were suffering from thyroid dis orders All these mothers have been examined and given thyroid tests

In order to be also able to evaluate the maternal thyroid disorders in association with neonatal hip pathology muscle specimens taken from the affected hips of all 10 infants were studied histologically Some specimens of shoulder muscles taken from the same infants were used as control specimens The criterion for dividing the mothers into two series was the clinical form of congenital hip pathology in the infants Two clinical forms were clearly dis tinguished These were (a) LAH and (b) AD In the same way a second unselected criterion arose viz the family history It is of some interest that accurate family history has been obtained with negative results for the first group in contrast to the second where a positive family history has been observed for all cases This point has been systematically studied Thus the first series consisted of 10 mothers who had children with LAH and a negative family history for this condition The second series concerned 9 mothers whose infants were afflicted with AD In this series all cases showed a positive family history of hip disorder All mothers came from the same geographic area The age distributions in both series were ap proximately the same

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Histological examination The morphol ogy (using light microscopy) of muscle specimens from the 10 infants suffering from LAH was studied The specimens were from the pelvifemoral, the pelvi trochanteric, and the gluteal groups A total of 30 specimens (one from each

muscle group) was examined Three facts emerged from this study a) There was *muscular degeneration in all cases*, b) The degeneration was more severe in younger children, c) There was considerable alteration in the muscles of the gluteal group

Almost all the specimens from the shoulder muscles showed the same histopathology, viz, variations in muscle fiber size, swelling, loss of myofibrils, vacuolation, and residual sarcolemmal nuclei The most constant finding was the vacuolation of the muscle fiber These findings are identical to those which occur in thyrotoxic myopathy It is well known that various myo-thyroidien syndromes show a predilection for the proximal girdle musculature (Kissel et al 1965, Danowski 1969)

Group II

A *Mothers who had infants with AD and a positive family history* The clinical and laboratory surveys of the nine mothers with a positive family history of CDH uncovered only two with a thyroid condition Both of them had simple goiterous enlargement, which functionally proved to be euthyroid

B *Affected infants* These dislocations were diagnosed at the age of 4–5 months All dislocated hips were associated with dysplastic acetabulae In addition, there were two cases of bilateral acetabular dysplasia, with the "good hip" at risk

Follow-up of these infants who had an acetabular index of over 28° and absence of the acetabular beak has not revealed spontaneous healing of the acetabular defect Five biopsied hips showed little organic change in the muscles Despite prolonged conservative treatment the epiphyseal nuclei are normal

CASE REPORTS

Case 1 (Group I) A 29 year old woman developed progressive nervousness palpitations and tiredness 6 months after a previous pregnancy The thyroid was diffusely enlarged and a fine tremor of the hands was present Her serum PBI level was greater than 11 μg/100 ml (normal range 3 5 to 8 μg) Radioiodine studies revealed diffuse uptake in normal tissue in both hyperplastic lobes of the thyroid Her first two infants had been normal whereas the third a girl had I AH Hip radiographs taken at the age of 3 days did not reveal any abnormality No treatment was given X ray taken after some months showed that both nuclei of ossification were completely fragmented Acetabulae were well formed

Case 2 (Group I) A 31 year old woman underwent subtotal thyroidectomy for toxic goiter in 1972 Two years later she became pregnant for the first time This was terminated by cesarean section because of cephalopelvic disproportion The infant has I AH and a nontoxic goiter At the age of 1 year her hips were found to be severely affected No splintage was used X ray of the pelvis demonstrated epiphyseal dysplasia bilaterally Acetabulae were well formed

Case 3 (Group I) A 24 year old woman had noticed a lump in her neck 4 years previously Clinical and laboratory studies confirmed the diagnosis of multinodular goiter Biopsy revealed changes of papillary adenocarcinoma *Her child a girl and* the product of a normal full term pregnancy was born with I AH Both hips were subluxated Although no treatment was given spontaneous reduction took place after 2 months Acetabulae are well developed

DISCUSSION

It is well known that the relative significance of genetic and exogenous factors varies from disease to disease and perhaps even from case to case All disease can be viewed as being part of a spectrum in this regard (McKusick 1969)

It has also been said that all disease has its causation In almost all of the common malformations, such as CDH the genetic component in the etiology is polygenic that is to say it involves genes at several gene loci What do we know about the etiology of CDH? It has been suggested by some, including Wynne Davies (1973) and Carter & Fairbank (1974) that the genetic factors are *probably related to joint laxity* and to

acetabular dysplasia, while the environmental factor which "triggers off" the dislocation in many cases is probably related to the breech malposition On the other hand, there is no example of polygenic inheritance in man which actually has been analyzed by a satisfactory method This is simply due to the fact that the methods used to elucidate polymeric inheritance are not applicable to man (Lenz 1961) A sporadic case of a malformation which is known to be inherited in some families may thus represent a phenocopy The distribution is important, since, if a genetic change is involved the probability of recurrence of the malformation in the family may be quite high, but if the malformation is a phenocopy the chance of recurrence will depend only on the chance of recurrence of the causal environmental factor, which may be extremely remote However, the causes of a phenocopy are not apparent and this fact can lead to deceptive interpretation of family histories

Perhaps the fluidity and confusion of confidences about the etiology of CDH might be attributed to this fact From this study there is already evidence that a large proportion of sporadic neonatal cases are phenocopies The present writer suggests that clinical material either as neonatal or late-diagnosis cases could well be a conglomeration of hereditary cases and phenocopies If this etiologic model is accepted further investigations in this field become extremely interesting

Conclusions

From this study of both mothers and infants, although it comprises a very small sample and is not statistically significant, it can be seen that limitation of abduction of the hips is a distinct variety of dislocation rather than a controversial clinical sign of it The validity and significance of the histological findings are obvious They are suggestive of a hitherto undescribed correlation between nonfamilial limited hip abduction and maternal thyroid disorders In this variety an error in muscle balance around the hips might be attributable to a reversible thyrotoxic myopathy. However, this matter is still awaiting elucidation

ACKNOWLEDGEMENTS

I wish to express my deep appreciation and thanks to Professors D Ikkos and D Koutras, two experts in thyroid disease, for their help and for the complete endocrinologic study of our clinical material made by them I also wish to thank Assistant Professor of Pathology D Papadimitriou for his careful examination of the specimens

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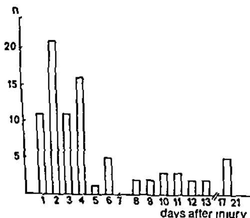


Figure 1 Interval between accident and arthroscopy In some patients treated initially at other hospitals arthroscopy was delayed

surgeon The procedure was always included in the normal operation list so that immediate operation could be carried out if necessary

Technique of arthroscopy

Our technique has been described earlier (Gillquist & Hagberg 1976) No tourniquet was used The 5 mm Storz arthroscope (Stille Werner Sweden) is introduced into the suprapatellar bursa through the patellar tendon Sterile water is flushed through the joint by an infusion pump (Sarns Model 5500 Stille Werner Sweden) and allowed to escape through a special needle (arthroscopy cannula Stille Werner, Sweden) inserted into the suprapatellar bursa About 2000 ml is required Hooks (Gillquist & Hagberg 1976) are used to test the menisci and the ligaments When indicated by the findings at arthroscopy arthrotomy is performed at the same session

PATIENTS

During the period 1972 to 1975 we performed 84 arthroscopies on 79 consecutive patients (66 men and 13 women) in the acute period after a knee injury The age of the patients ranged between 15 and 60 years and most (55 patients) were between 15 and 30 Soccer was a prominent cause of injury and together with other sports accounted for 63 per cent of all cases

Time of arthroscopy (Figure 1)

Seventy per cent of the arthroscopies were performed within the first 4 days after the accident In some cases the interval was longer as the patients had first been treated at other hospitals These patients also fulfilled the criteria of haemarthrosis or locking

RESULTS

Figure 2 shows the diagnosis arrived at during arthroscopy or arthrotomy The anterior cruciate ligament was injured in 50 per cent of the injured knees Combined injury of the anterior cruciate ligament, medial meniscus, and the medial collateral ligament was the commonest finding In fact, combined injuries were the rule Acute locking of the joint was an unreliable sign of meniscus lesion Out of 28 patients with a locked knee only 12 showed tears of the meniscus (10 medial and 2 lateral) Most others showed partial rupture of the medial collateral ligament

Haemarthrosis

Haemarthrosis was present in 69 arthroscopies (Table 1) The commonest

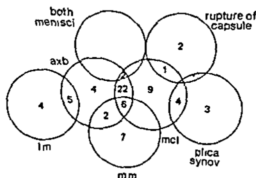


Figure 2 Diagram showing the combination of injuries found at 84 arthroscopies There were also three patients with rupture of the posterior cruciate ligament two with dislocation of the patella seven with a chondral fracture and one with a ruptured patellar tendon strip after reconstruction of the anterior cruciate ligament Two patients with rupture of the anterior cruciate ligament and lateral meniscus also showed partial rupture of the medial collateral ligament Ten showed partial rupture of the anterior cruciate ligament (For abbreviations see text to Table 3)

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ARTHROSCOPY IN ACUTE INJURIES OF THE KNEE JOINT

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Arthroscopy was performed during the acute phase of injury in 81 knees (79 patients) A satisfactory view of the joint was obtained in all cases, and no complications occurred About two thirds of the patients had injuries associated with violent rotation abduction In about one third of the patients operation could be avoided In cases with haemarthrosis, serious ligament injury was present in nearly 50 per cent Complete arthroscopy was associated with few diagnostic errors Clinical examination often led to uncertain or incorrect diagnosis even when performed under anaesthesia by experienced surgeons In contrast, arthroscopy led to rapid diagnosis and treatment thus shortening the period of disability We recommend arthroscopy in acute knee injuries, but the examination must be performed by an experienced arthroscopist

Key words endoscopy, arthroscopy, knee injury, knee joint haemarthrosis

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Early diagnosis of injuries of the knee joint is of great importance, in order to prevent disability (Liljedahl & Nordstrand 1969, Alm 1974) However, common diagnostic methods often fail during the acute stage of a knee injury (Liljedahl et al 1965) In recent years arthroscopy has been used with great success in diagnosis of non-acute cases of knee joint trauma or disease (Jackson & Abe 1972, Dandy & Jackson 1975, Casscells 1971, Wruhs 1970, Watanabe et al 1968, Gallannaugh 1973, Alm et al 1974, Gillquist & Hagberg 1976) Jackson (1974) and O'Connor (1974) reported that arthroscopy might be of value in acute injuries Some preliminary experiments with arthroscopy in the acute stage (Gillquist & Hagberg 1976) led us to test the technique in a larger series of consecutive patients over the past few years This paper summarizes our experiences

METHODS

Indications for arthroscopy

Patients admitted to the emergency department with acute knee injury with haemarthrosis or acute locking with effusion were included Locking was defined as an extension defect with an elastic resistance against forced extension The diagnosis of haemarthrosis was made when swelling of the joint took place immediately after trauma and blood was aspirated from the joint Patients were examined on admission immediately after aspiration of the distended joint A preliminary diagnosis was made, and the patient was admitted to hospital Straight X ray films were always taken on admission

Arthroscopy was carried out as soon as possible after admission usually within a few days by an experienced arthroscopist the joint being first examined under general anaesthesia by the

Table 3 Number of patients with different diagnoses included in groups I–III

Type of injury	Group I Operation avoided	Group II Change of surgical procedure	Group III Arthroscopy superfluous	Total
acl (partial rupture) + mcl	4	5	1	10
acl + mm	–	–	2	2
acl + lm	1*	1	1	3
acl + mcl + mm	–	2	4	6
acl + mcl + lm		1	1	2
acl + mcl + mm + lm		1	1	2
acl (3 with fracture)	–	2	2	4
mcl (1 capsular rupture)	9	–	1	10
mm	–	3	4	7
lm (1 with fracture)	–	4	–	4
plica synovialis (+ 5 with mcl)	6	–	1	7
pcl	–	3	–	3
osteochondral fracture	4	1	2	7
capsular rupture	1	–	1	2
patellar dislocation	1	1	–	2
rupture of reconstructed anterior cruciate ligament		1	–	1
Total	26	31	27	84

* This patient showed partial rupture of the anterior cruciate ligament a small rupture of the lateral meniscus and severe osteoarthrosis Operation was not performed
acl = the anterior cruciate ligament mcl = medial collateral ligament mm = medial meniscus lm = lateral meniscus pcl = posterior cruciate ligament

rupture of the lateral meniscus was also overlooked In these cases indication for operation had already been established by the arthroscopic demonstration of a ruptured anterior cruciate ligament

Misinterpretation and technical errors

This group comprises three patients subjected to unnecessary operations The first patient with a rupture of the plica lata was erroneously operated on with a diagnosis of rupture of the anterior cruciate ligament In another patient with a fracture of the eminentia intercondyloidea without dislocation a small rupture of the medial meniscus was diagnosed at arthroscopy During arthrotomy, however the rupture was found to be insignificant

The third patient had a linear rupture of the capsular attachment of the medial meniscus diagnosed at arthroscopy During operation a rupture of the capsule was seen but the meniscus was thought to be intact However, the patient had to be subjected to reoperation after further trauma a few months later He then showed a dislocated medial meniscus The significance of the arthroscopic finding had thus been underestimated during the first operation

Diagnostic value of arthroscopy

The diagnosis arrived at during arthroscopy was compared with the diagnosis made after X ray examination (mostly straight films) and clinical examination under anaesthesia by an experienced surgeon The patients were arranged in three groups according to the diagnostic contribution made by arthroscopy in each case Group I consists of

finding was rupture of the medial collateral ligament in combination with tearing of the anterior cruciate ligament Rupture of the anterior cruciate ligament was present in 64 per cent of the 69 cases with haemarthrosis However, the rupture was partial and did not necessitate operation in 10 cases Rupture of the medial collateral ligament was diagnosed by *valgus instability*, and at arthroscopy a wide medial recess or haemorrhage from the ruptured medial synovia was found In some cases rupture of the deep portion of the ligament could be demonstrated The arthroscopic findings do not permit differentiation of partial and total ruptures of the medial collateral ligament, however, and this was done by testing the valgus instability In seven cases a rupture of the plica synovialis was found to be the sole source of the haemarthrosis, and this together with partial rupture of the medial collateral ligament was present in five cases Rupture of the joint capsule was an uncommon cause of haemarthrosis

Table 1 Injuries in patients showing haemarthrosis ($n = 69$) In many cases the various injuries occurred in combination (see also Figure 2)

Type of injury	*n*	Per cent
Total rupture of the anterior cruciate ligament	31	45
Partial rupture of the anterior cruciate ligament	10	14
Total rupture of the posterior cruciate ligament	2	3
Total or partial rupture of the medial collateral ligament	41	59
Rupture of a meniscus	16	23
Osteochondral fracture	7	10
Dislocation of the patella	2	3
Rupture of the plica synovialis	7	10
[illegible]	3	4
of the anterior cruciate ligament)	1	

Table 2 Diagnosis at arthroscopy or arthrotomy in 15 patients without haemarthrosis

Diagnosis	No
Rupture of	
medial meniscus	7
lateral meniscus	3
medial collateral ligament	4
posterior cruciate ligament	1
Total	15

Cases with no haemarthrosis

The diagnosis in these 15 cases is shown in Table 2 The commonest lesion was ruptured meniscus One patient showed rupture of the tibial insertion of the posterior cruciate ligament without haemarthrosis There were no ruptures of the anterior cruciate ligament in this group

Follow-up examination

In 30 patients arthroscopy was not followed by operation They were followed up for 1 year and most regained full activity In two patients total rupture of the anterior cruciate ligament and partial rupture of the medial collateral ligament were not treated by operation In one of them arthroscopy was performed under epidural anaesthesia and the patient wished to postpone operation The other was an obese, 40 year-old woman alcoholic, injured while drunk Apart from the cruciate ligament injury she also had severe osteoarthrosis Operation was not considered to be indicated In both cases the knee joint was unstable and the patients were disabled at the follow-up examination

Diagnostic errors

In five cases (9 per cent) there was some lack of correlation between the arthroscopic picture and the findings at operation In four of these a linear rupture of the posteromedial part of the medial meniscus was not diagnosed One

cruciate ligament at its normal site often led us to the diagnosis Moreover after some days arthroscopy becomes more difficult as the blood in the joint causes synovitis and the bulging synovia often tends to obstruct the field Because of these problems arthroscopy of an acute knee injury should only be undertaken by a surgeon with great experience of arthroscopy *in non acute cases*

The fact that haemarthrosis is a sign of serious injury is demonstrated by the present series In 46 per cent of patients with haemarthrosis a lesion of the anterior cruciate ligament was present in association with partial rupture of the medial *collateral ligament and sometimes* also with rupture of the meniscus (the unhappy triad O Donoghue 1950) However in 10 of these patients only a partial *rupture* of the anterior cruciate ligament was found The unhappy triad leads to permanent disability if left untreated (Alm 1974) and treatment is more complex if delayed (*O Donoghue et al 1966* Brostrom et al 1968 Gillquist et al 1971 Alm et al 1974) If all our patients had been initi

tients with haemarthrosis rupture of a meniscus was usually *combined* with lesions of the ligaments whereas when n haemarthrosis was present a *single* rupture of a meniscus was the commonest finding Rupture of the *joint* capsule alone was an infrequent cause of haemarthrosis The *conclusion* is therefore that a patient with *haemarthrosis* should be regarded as having a *serious* ligament injury until this has been *dis*proved

Our series also demonstrates the insufficiency of *clinical* examination even when performed under anaesthesia *by an* experienced surgeon In fact even when we later judged the arthroscopy to have been superfluous many of the patients could not have been safely distinguished from the other groups by clinical examination alone However the clinical diagnosis was always correct when *marked* instability was present Thus in such cases arthroscopy seems unnecessary This series includes some patients in whom more than one experienced surgeon clinically diagnosed rupture of the medial meniscus that during arthroscopy proved to be rupture of the lateral one calling for a completely different approach Smillie (1970) also drew attention to this problem Locking of the knee joint with extension *defect* was *interpreted* at the clinical examination as *being a sign of rupture of the meniscus* At arthroscopy however no injury of this kind could be found in more than half of the cases In the present series very few men se e m

In seven cases arthroscopy *also dis*closed a type of knee injury not previously described a rupture of the plica synovialis In the first case the diagnosis *was confirmed* at operation It might be *argued that the* introduction of the arthroscope through the patellar tendon might have caused the injury The fact that the lesion has never been observed in any of our non acute arthroscopies is evidence against this The association *with* a partial rupture of the medial collateral ligament might indicate that the *injury represents the initial stage of the* rotational force resulting in the unhappy triad

In conclusion we have found arthroscopy to be a very safe reliable and useful diagnostic method in cases of acute knee trauma About two-thirds of the patients ed
pair
third
safely avoided Only three patients were *subjected* to unsuccessful arthrotomy No complications *occurred*

patients in whom operation could be avoided as a result of arthroscopy and Group II of patients in whom the surgical approach was *changed* When the clinical examination was completely in accordance with the arthroscopic diagnosis the arthroscopy was regarded as having been unnecessary (Group III) Patients in whom diagnostic errors, misinterpretations, and technical errors occurred were also referable to groups II–III Clinical examination at the emergency department gave correct findings in only 15 per cent of cases Subsequent examination under anaesthesia gave correct findings in only 32 per cent of the patients In patients with ruptured meniscus the diagnosis was correct in 63 per cent

Group I Operation avoided (26 cases) In this group, clinical examination on admission, examination under anaesthesia and straight X-ray failed to result in a conclusive diagnosis In eight patients the knee was locked, simulating rupture of a meniscus Other patients showed haemarthrosis and a suspected drawer sign forwards, or fractures were present possibly indicating rupture of the anterior cruciate ligament Four with partial rupture of the anterior cruciate and medial collateral ligaments were included (Table 3)

Group II Change of surgical procedure (31 cases) In this group most patients showed marked haemarthrosis Ligament injury was suspected but could not be confirmed Seven of the 10 patients with a rupture of the lateral meniscus were in this group (Table 3) It was often impossible to distinguish clinically between these patients and the patients of group I with haemarthrosis

Group III Arthroscopy superfluous (27 cases) Here the clinical diagnosis was clear Of 31 patients with total rupture of the anterior cruciate ligament, 17 were included in this group, as were also 11 out of 17 with ruptured medial meniscus (Table 3) Many of these patients were referred to us for arthroscopy from other hospitals An experienced surgeon established the diagnosis by clinical examination, and this was confirmed by arthroscopy

Complications

No infections occurred Bacterial cultures of the irrigation fluid before and after arthroscopy were always negative No adverse effects resulted from flushing with sterile water In two patients slight pain at the site of introduction of the instrument disappeared after a few weeks In no case was the field of view obstructed by haemorrhage in the joint even though fresh bleeding sometimes occurred during the procedure

DISCUSSION

Arthroscopy of an acutely injured knee joint with haemarthrosis presents several difficulties This is probably why some clinicians regard the condition as a contraindication to the procedure (Casscells 1971, Jackson & Abe 1972, Henche 1974, Glinz 1974) On the other hand early diagnosis of an intra-articular injury has several advantages (Liljedahl & Nordstrand 1969, Gillquist et al 1971, Alm 1974), and efforts to overcome the difficulties will be rewarded However the haemarthrosis necessitates irrigation of the joint We have tested several means of doing this (Gillquist & Hagberg 1976) Our present technique using an infusion pump, arthroscopy cannula, and sterile water has proved entirely satisfactory

Another problem was the new, unfamiliar picture of an acute knee injury It was sometimes difficult to demonstrate rupture of the anterior cruciate ligament, as the tissue was so fragmented However, the absence of the

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TOTAL HIP REPLACEMENT BY THE BRUNSWIK PROSTHESIS

A Preliminary Report of 189 Operations

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The results of 189 Brunswik total hip replacements performed at the Orthopaedic Hospital of the Invalid Foundation Helsinki Finland and followed up for 2-3 years are presented According to the modified system of Merle D Aubigne & Postel excellent results were achieved in 11 1 per cent (21/189) good in 56 6 per cent (107/189) and fair in 27 5 per cent (52/189) The failure rate was 4 8 per cent (9/189) and consisted of four deep infections four cases of aseptic loosening and one case of allergic loosening Local complications occurred after primary operations in 7 5 per cent (12/159) and after revision operations in 26 7 per cent (8/30) and the difference was statistically significant ($P < 0 01$) Among the complications deep infections were encountered in 2 6 per cent (5/189) aseptic loosenings in 2 1 per cent (4/189) Other local complications were ectopic ossification in 1 6 per cent (3/189) nerve injuries in 1 6 per cent (3/189) dislocations in 1 1 per cent (2/189) and peroperative fractures in 1 1 per cent (2/189) General complications were observed in 8 9 per cent (17/189) Thrombo embolic complications were only seen in 2 6 per cent (5/189) A possible explanation for this low figure was the early ambulation of the patients on the first postoperative day No deaths related to the operation occurred

Key words total hip replacement metal to metal prosthesis metal to plastic prosthesis

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Total hip replacement was first performed at the Orthopaedic Hospital of the Invalid Foundation in 1967 with the McKee-Farrar prosthesis and this prosthesis has been used in a total of 555 hips Two reports have been published of the results (Langenskiold & Salenius 1970 Salenius & Laurent 1973) After an increasing number of aseptic loosenings of this prosthesis we changed from the metal to-metal prosthesis to the metal to-plastic prosthesis in December 1972 preferring the Brunswik prosthesis

The design and size of the Brunswik prosthesis has been described by Lubinus (Lubinus & Jacobsen 1973)

The purpose of this paper is to present the results of the first 189 applications and to analyse the complications of this procedure

PATIENTS AND METHODS

The patients were operated on between December 1972 and March 1974 The minimum follow up time was 2 years varying from 2 0 to 3 0

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TOTAL HIP REPLACEMENT BY THE BRUNSWIK PROSTHESIS

A Preliminary Report of 189 Operations

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The results of 189 Brunswik total hip replacements performed at the Orthopaedic Hospital of the Invalid Foundation, Helsinki, Finland, and followed up for 2–3 years, are presented According to the modified system of Merle D Aubigne & Postel excellent results were achieved in 11 1 per cent (21/189), good in 56 6 per cent (107/189) and fair in 27 5 per cent (52/189) The failure rate was 4 8 per cent (9/189) and consisted of four deep infections four cases of aseptic loosening and one case of allergic loosening Local complications occurred after primary operations in 7 5 per cent (12/159) and after revision operations in 26 7 per cent (8/30) and the difference was statistically significant ($P < 0\ 01$) Among the complications, deep infections were encountered in 2 6 per cent (5/189), aseptic loosenings in 2 1 per cent (4/189) Other local complications were ectopic ossification in 1 6 per cent (3/189) nerve injuries in 1 6 per cent (3/189), dislocations in 1 1 per cent (2/189), and peroperative fractures in 1 1 per cent (2/189) General complications were observed in 8 9 per cent (17/189) Thromboembolic complications were only seen in 2 6 per cent (5/189) A possible explanation for this low figure was the early ambulation of the patients on the first postoperative day No deaths related to the operation occurred

Key words total hip replacement, metal-to-metal prosthesis, *metal to plastic prosthesis*

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Total hip replacement was first performed at the Orthopaedic Hospital of the Invalid Foundation in 1967 with the McKee-Farrar prosthesis, and this prosthesis has been used in a total of 555 hips Two reports have been published of the results (Langenskiöld & Salenius 1970, Salenius & Laurent 1973) After an increasing number of aseptic loosenings of this prosthesis, we changed from the metal to-metal prosthesis to the metal-to-plastic prosthesis in December 1972 preferring the Brunswik prosthesis

The design and size of the Brunswik prosthesis has been described by Lubinus (Lubinus & Jacobsen 1973)

The purpose of this paper is to present the results of the first 189 applications and to analyse the complications of this procedure

PATIENTS AND METHODS

The patients were operated on between December 1972 and March 1974 The minimum follow-up time was 2 years varying from 2 0 to 3 0

Table 1 Sex and age distribution at operation

Years	20–29	30–39	40–49	50–59	60–69	70–79	80–85	Total
Women	2	0	12	28	68	23	1	134
Men	1	0	5	15	16	9	0	46
Total	3	0	17	43	84	32	1	180

years The series consisted of 183 patients, but two of them died from causes unrelated to the hip operation and one schizophrenic patient refused to come for follow-up examination Thus the series consists of 180 patients and 189 hips, nine patients being operated on bilaterally The age and sex distribution of the patients are given in Table 1 The mean age was 61 9 years The youngest patient was 25 and the oldest 84 years old The preoperative diagnoses are listed in Table 2 In 30 patients some kind of hip operation had been performed prior to the arthroplasty (Table 3) This group is called the revision group

Because of the rather big acetabular component of the Brunswik prosthesis which proved to be too large for many female hips, we have used a smaller metal to-plastic prosthesis, the French Lagrange-Letournel model in such cases (Lagrange & Letournel 1974)

Table 2 Preoperative diagnosis

Primary osteoarthritis	142
Rheumatoid arthritis	11
Posttraumatic arthritis	11
Congenital hip dislocation	6
Old osteomyelitis	4
Legg Perthes' disease	3
Old tuberculous coxitis	1
Slipped epiphysis	1
Post radiation necrosis	1
Total	180

Table 3 Previous operations

Intertrochanteric osteotomy	17
Thompson Austin Moore arthroplasty	4
McKee Farrar arthroplasty	4
Nailing of fracture of the neck of the femur	3
Vitallium cup arthroplasty	1
Skin arthroplasty	1
Total	30

Operation and postoperative care

All patients were operated through an antero lateral approach according to the technique published by McKee & Farrar in 1966 A post operative antibiotic prophylaxis started on the first postoperative day was administered to all but 28 patients for 8 days (Three of the five deep infections occurred among the patients who did not receive antibiotic prophylaxis) Ampicillin was used in most cases Prophylactic anticoagulants were not used, only established thromboembolism was treated The patients were mobilized on the first postoperative day allowing immediate weight bearing The operations were performed in conventional operating theatres No air-conditioning or laminar air flow system was available In high risk patients a preoperative examination by a specialist in internal medicine was carried out High risk patients were often operated on under hemi spinal anaesthesia Statistics concerning operation time, blood loss and anaesthesia are given in Table 4

RESULTS

The results were evaluated according to a modified system of Merle D'Aubigne & Postel (1954) with six gradations for pain, motion and walking ability

Pain (Figure 1) 76 7 per cent (138/180) of the patients suffered continuous or intermittent pain at rest before the operation The relief of pain was marked and 67 7 per cent (122/180) were pain-free after operation 2 8 per cent (5/180) of the patients still had restrictive pain, in four cases this was due to deep infection and in one case to aseptic loosening In three other cases of aseptic loosening the pain was tolerable The average score for pain was 2 36 be

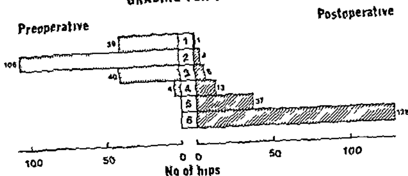


Figure 1 Numerical grading for pain pre and postoperatively in 189 Brunswik total hip replacements

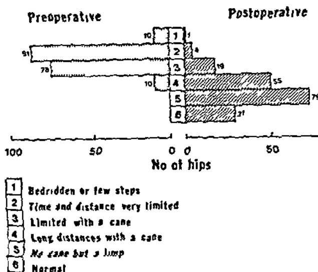


Figure 2 Numerical grading for function pre and postoperatively in 189 Brunswik total hip replacements

fore and 5 40 after the operation with an improvement of 3 04 *points*

Function (Figure 2) Normal gait was achieved by 17.2 per cent (31/180) of the patients 70 0 per cent (126/180) of the patients had a slight limp or used a cane but could walk long distances In 12 8 per cent (23/180) the function was limited The recovery of function was less marked than the improvement in pain The improvement rate was on average 2 13 points

Mobility (Figure 3) The recovery of mobility was very similar to that of function with an improvement of 2 24 points A flexion contracture was present in 30.2 per cent (57/189) of the hips before the operation 5–10° in 23 cases, 10–20° in

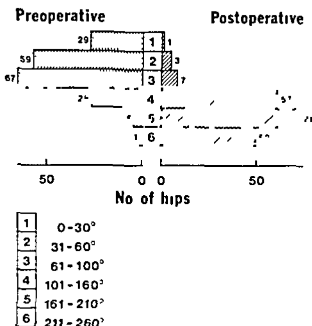


Figure 3 Numerical grading for mobility pre- and postoperatively in 189 Brunswik total hip replacements

11 and 30–40° in 23 cases Correction of this contracture was obtained in all but four patients In three of these patients flexion contracture was caused by a massive myositis ossificans and in one a 10° contracture remained

Overall results (Table 5)

11 1 per cent (21/189) of the hips were classified as excellent there was no pain, normal gait was achieved and the range of movement of the hip was over 210° In 56 6 per cent (107/189) the result was good i e, there was no pain, but there was a limp or a cane was needed for long distances 27 5 per cent (52/189) were *classified as fair* The patients had slight or moderate pain and the walking distance was limited The failure rate was 4 8 per cent (9/189) This group consisted of four cases of deep infection four cases of aseptic loosening and one case of allergic loosening The results according to the preoperative diagnosis are given in Table 5

Complications

General complications These are listed in Table 6 There were very few general complications in this series No death related to the operation occurred Deep venous thrombosis developed in four patients postoperatively and pulmonary embolism in one patient 3 weeks after the operation The diagnosis of thrombosis was based on clinical observation only The thrombosis was treated by heparin and oral anticoagulants No late sequelae following thrombosis were observed at the follow-up examination Cardiac ischaemia was diagnosed in two cases There were also three cases of postoperative pneumonia All general infections responded to antibiotic treatment

Local complications Local complications occurred in 20 patients Local com

Table 4 Operation statistics

Surgeons	11
General anaesthesia	146
Hemispinal anaesthesia	43
Blood loss in primary operation	1360 ml average
Blood loss in revision operation	1430 ml average
Blood loss in hemispinal anaesthesia	1370 ml average
Blood loss in general anaesthesia	13?0 ml average
Blood loss in all operations	1370 ml average
Blood loss from drains	?75 ml average
Transfusion total	4 7 units average
Operation time	110 min average

Table 5 Results according to the system of Merle D Aubigne

	Primary osteoarthritis	Secondary osteoarthritis	Rheumatoid arthritis	Revision arthroplasty	*All hips*
Excellent (grading 6–6–6)	19	–	2	–	21 (11 %)
Good (minimal grading 6–4–3)	79	9	7	13	107 (57 %)
Fair (minimal grading 3–3 2)	29	8	3	12	52 (27 %)
Poor (grading under 3–3 2)	2	2	–	5	9 (5 %)
Total	129	19	12	30	189 (100 %)

Table 6 Complications

	Primary operation (159 hips)		Revision operation (30 hips)		All	
	No	Per cent	No	Per cent	No	Per cent
A *General*						
Deep venous thrombosis	3	1 9	1	3 3	4	2 1
Pulmonary embolism	1	0 6	–		1	0 5
Cardiac ischaemia	2	1 3	–		2	1 1
Pneumonia atelectasis	3	1 9	1	3.3	4	2 1
Urinary infection	4	2 5	1	3 3	5	2 6
Cholecystitis	1	0 6	–		1	0 5
Total	14	8 8	3	10 0	17	8 9
B *Local and technical*						
Deep infection	2	1.3	3	10 0	5	2 6
Aseptic loosening	1	0 6	3	10 0	4	2 1
Myositis ossificans	3	1 9	–		3	1 6
Nerve damage	3	1 9	–		3	1 6
Dislocations	2	1.3	–		2	1 1
Peroperative fractures			2	6 7	2	1 1
Loose cement bodies	1	0 6	–		1	0 5
Total	12	7 5	8	26 7	20	10 6

plications were seen in 12 patients after primary operation and in 8 patients after revision operation This difference is statistically significant ($P < 0\ 01$)

There were five deep infections in this series The course and treatment, and the bacteria of the infected hips, are given in Table 7

Three of the four aseptic loosenings were caused by malpositioning of the prosthesis One case of allergic loosening, proved by a skin sensitivity test, was

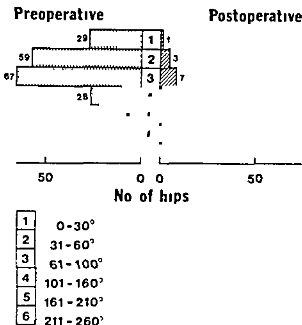


Figure 3 Numerical grading for mobility pre- and postoperatively in 189 Brunswil total hip replacements

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Blood loss in all operations	1370 ml average
Blood loss from drains	575 ml average
Transfusion total	4 7 units average
Operation time	110 min average

of infections

Time of infection	Appearance of infection	Treatment	Final result
Early	Sinus	Debridement irrigation	Good
Early	Sinus loosening of femoral part	Debridement irrigation reapplication of femoral part, removal of prosthesis	Girdlestone
Early	*Loosening of femoral part*	*Reapplication of femoral part*	*Good*
Late 4 months	Loosening of both parts	Removal of prosthesis	Girdlestone
Late 5 months	Sinus loosening of both parts	Debridement irrigation removal of prosthesis	Girdlestone

postoperative complications particularly thromboembolism is early mobilization of the patient The rate of thromboembolic complications in our series was 2 6 per cent without the use of anticoagulants This low figure is comparable to the incidence of thromboembolic complications in patients treated prophylactically with dextran 40 or sodium warfarin (Evarts 1974 Beckenbaugh et al 1974)

It is difficult to compare the results of total hip replacement reported by different authors because the systems of evaluation vary It is more reliable to compare the number of failures In our series the local failure rate was 4 8 per cent and in Lubinus series 3 7 per cent (Lubinus 1973) The results of Brunswik operations are highly satisfactory and we intend to continue using the Brunswik prosthesis

ACKNOWLEDGEMENT

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Table 7 The course

Patient	Previous operation	Prophylactic antibiotic	Bacterium
AR	None	None	Staphylococcus aureus
VM	Displacement osteotomy	None	Pseudomonas
FP	Displacement osteotomy	Ampicillin	Staphylococcus aureus
IS	None	None	Staphylococcus epidermidis
AH	McKee Farrar total hip prosthesis	Cloxacillin	Staphylococcus aureus

seen after reapplication of a loosened McKee-Farrar prosthesis Two peroperative fractures occurred In three cases a massive heterotopic ossification developed causing stiffness of the hip Three cases of peroperative nerve damage occurred There were two injuries to the femoral nerve, one recovered completely, the other seems to be permanent There was one sciatic nerve injury, which was due to a posterior dislocation of the femoral part of the prosthesis This palsy has partly disappeared Dislocations occurred in two patients One was caused by a fall The other was due to a too vertical insertion of the acetabular part

DISCUSSION

We have encountered some difficulties with both the acetabular and the femoral parts of the Brunswik prosthesis Because of its large size the Brunswik socket is easily inserted in a too vertical position It fits the acetabulum best in a vertical position Two complications resulted from this vertical insertion of the socket, one dislocation and one loosening of the cup On the other hand, the big socket has proved very suitable in cases of deep acetabular protrusion, as is often seen in rheumatoid arthritis

We have also encountered difficulties in the positioning of the standard femoral parts in femora osteotomized earlier Three local complications (2 loosenings and 1 fracture) accompanied these difficulties It is evident that a specially designed straight stem is necessary in such cases

If one compares the local complications of our McKee-Farrar series after 3 years observation (Salenius & Laurent 1973) with those of the Brunswik operations, there are two differences One is a decrease in the rate of deep infections from 4 8 per cent to 2 6 per cent This difference may be explained by the use of systemic antibiotic prophylaxis, because the other conditions remained the same The most marked difference between the operations is, however, a decrease in aseptic loosenings The incidence of aseptic loosenings in the McKee-Farrar series was 12 5 per cent (18/143) six times higher than that in the Brunswik series (2 1 per cent) After 6–7 years follow-up this figure has doubled We do not expect such a high incidence of aseptic loosenings in our Brunswik series This difference justified the change from an all-cobalt chrome prosthesis to a metal-to-plastic prosthesis

The frequency of general complications in large series of hip arthroplasties has been reported to be 13–25 per cent (Ilstrup et al 1973, Coventry et al 1975) Lubinus reports a frequency of 15 per cent (Lubinus & Jacobsen 1973) In our series the frequency was 8 9 per cent with no death related to the operation The most important factor preventing

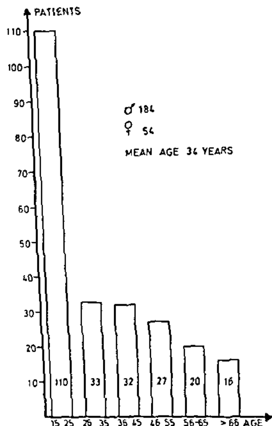


Figure 1 Age distribution of 238 patients with tibial shaft fractures

(Muller et al 1963, 1970) have been widely accepted in a number of European countries and the USA, relatively few papers have been published on the results of compression osteosynthesis in fractures of the tibial shaft (Infanger et al 1971, Olerud & Karlström 1972, Rüedi et al 1976, Solheim 1973, Smith 1974)

We therefore consider it of interest to compare the results of treatment with AO plates, conventional Eggers or Lane plates and conservative treatment

PATIENTS AND METHODS

During the period July 1966 to April 1975 238 patients over the age of 15 with tibial shaft fractures, were treated as in patients at the Department of Orthopaedic Surgery, Frederiks borg County Hospital, Hillerød, Denmark The age distribution is shown in Figure 1

The tibial shaft was defined as the area from 7 cm below the knee joint to 7 cm above the ankle joint Table 1 compares the type of fracture and the cause of injury and it can be seen that the majority of comminuted and transverse fractures were caused by high velocity traumas Multiple injuries including other severe fractures or body injuries were found in 55 patients

Thirty nine per cent were open fractures (93/238) and could be classified as follows *Grade I* simple skin perforation from within, *Grade II* skin perforation from without including minor skin or muscle contusion, *Grade III* extensive soft tissue damage with major loss of skin sometimes associated with lesions of vessels or nerves Table 2 lists the open fractures according to the cause of injury, 74 out of 93 open fractures (80 per cent) were due to traffic accidents The method of treatment is correlated to the cause of injury in Table 3 and to the type of fracture in Table 4 Thirty-one patients were treated with "other operative methods", including interfragmentary compression with lag screws in 16 cases, medullary nailing in 5, Rush-pinning in 4 cerclage wires in 3 and external fixation with Hoffman apparatus in 2 cases In one case a primary above knee amputation was performed This group of patients have been excluded from the follow up, because the intention was to compare only conservative treatment and the two types of plate osteosynthesis

The standard treatment of fractures of the tibial shaft has been conservative with closed reduction and immobilization in a high plaster cast If conservative treatment did not lead to stable reduction with anatomical alignment, osteosynthesis was performed within the first 48 hours after admission In the period 1966 to 1970, plate osteosynthesis was performed with open reduction and fixation of the fracture with conventional Eggers or Lane plates, followed by immobilization in a high plaster cast. Since 1970, AO compression plates have been used with open reduction and application of interfragmentary compression with lag screws combined with neutralization plates, or axial compression plates of the AO type (Muller et al 1970) In these cases no cast was applied and immediate training for joint mobility was started, followed by early non weight bearing mobilization Full weight bearing was allowed in all groups when the fracture was considered united and normal muscle and joint function had been obtained

All tibial shaft fractures whether open or closed have been treated according to these

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TIBIAL SHAFT FRACTURES

A Comparison of Conservative Treatment and Internal Fixation with Conventional Plates or AO Compression Plates

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Out of a series of 207 consecutive fractures of the tibial shaft 102 were treated conservatively 64 fractures were treated by AO compression plate osteosynthesis and 41 by internal fixation using Eggers or Lane plates The choice of method was independent of the extent of soft tissue damage A follow up examination of 199 fractures with a mean observation time of 3 4 years revealed residual malalignment in 21 per cent of conservatively treated cases and in 8 per cent after conventional plate fixation while the AO method resulted in anatomical restoration of the axis of the tibia in all cases However removal of the compression plates was followed by re fractures early and late in 11 per cent Implant failure occurred in 5 per cent of both types of plate fixation and 3 per cent of the conservatively treated cases redislocated Infection developed in 5 per cent of closed fractures and in 11 per cent of open fractures treated by operative means Of the conservatively treated cases only 3 per cent of the open fractures developed infection The risk of infection following acute internal fixation is thus four times greater than with conservative treatment AO compression plate fixation shortened the time of fracture healing considerably The rate of non union after conservative treatment was 6 per cent in closed and 21 per cent in open fractures Similarly in conventional plate fixation there was non union in 8 and 24 per cent respectively Non union was not encountered after AO compression plate osteosynthesis It is concluded that AO plate osteosynthesis is justified in the treatment of open tibial shaft fractures and also useful in closed fractures when conservative treatment does not lead to stable reduction with a good alignment

Key words tibial shaft fractures osteosynthesis infection osteosynthesis non union internal fixation AO compression osteosynthesis Eggers plates Lane plates

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The ideal treatment for tibial shaft fractures is still a controversy The problems involved have been thoroughly described in a whole volume of *Clinical Orthopaedics and Related Research* (*Clin Orthop* 105 1974) edited by A Sarmiento with contributions from several authors with solid experience in this field Although the principles of the AO group

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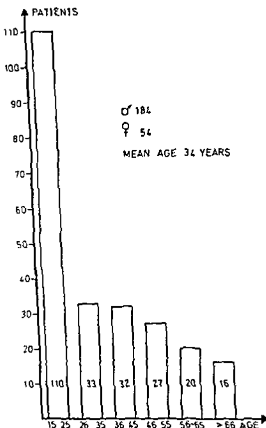


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Thirty nine per cent were open fractures (93/238) and could be classified as follows *Grade I* simple skin perforation from within *Grade II* skin perforation from without including minor skin or muscle contusion *Grade III* extensive soft tissue damage with major loss of skin sometimes associated with lesions of vessels or nerves Table 2 lists the open fractures accord ng to the cause of injury 74 out of 93

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All tibial shaft fractures whether open or closed have been treated according to these

Table 1 Type of fracture/cause of injury

	Traffic accident	Fall	Work accident	Sports injury
Oblique fracture	34	35	9	11
Transverse fracture	39	1	2	21
Comminuted fracture	67	6	4	9

Table 2 Cause of injury/extent of soft tissue damage

	Total no	Open fractures			
		Grade I	Grade II	Grade III	Total
Traffic accident	140	26	37	11	74
Fall	42	7	1		8
Work accident	15	1	3	1	5
Sports injury	41	2	4		6
Total no	238	36	45	12	93

Table 3 Cause of injury/method of treatment

	Conservative treatment	Operative treatment		
		AO plates	Eggers/Lane plates	Other methods
Traffic accident	60	39	28	13
Fall	15	12	4	11
Work accident	6	4	2	3
Sports injury	21	9	7	4
Total no	102	64	41	31

Table 4 Type of fracture/method of treatment

	Conservative treatment	Operative treatment		
		AO plates	Eggers/Lane plates	Other methods
Oblique fracture	32	27	9	19
Transverse fracture	37	8	14	4
Comminuted fracture	33	29	18	8
Total no	102	64	41	31

principles In open fractures systemic antibiotics were administered routinely

A clinical and roentgenological follow up study of the knee the ankle and the entire tibial shaft in two planes was performed in 199 of the 207 patients treated according to these principles after a mean observation time of 3.4 years (Figure 2) Three patients died during hospitalization and five patients were lost to follow up

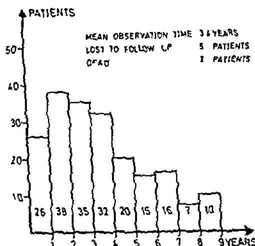


Figure 2 Period of observation at follow-up of 199 patients

Table 5 General complications among 207 patients

	Conservative treatment	Operative treatment
Cardio pulmonary	2*	2
Pulmonary embolism		2*
Fat embolism	4	4
Phlebo thrombosis	1	1
Peroneal palsy	2	2
Total no.	9	11
Died in hospital	1	2

* Fatal complications in 3 patients

RESULTS

General complications (Table 5) were encountered in 10 per cent of the patients (20/207) There was no difference between the conservative and operative group There were eight patients with fat embolism, seven had femoral shaft fractures and one multiple injuries Three patients died in hospital, in two cases the cause was pulmonary embolism and in one case it was cardiopulmonary complications

Local complications were encountered in 30 per cent of the patients (61/207) Dislocation following conservative treatment was seen in 3 per cent (3/102) *leading to secondary osteosynthesis* Implant failure occurred in three cases after AO plate osteosynthesis and in two cases after conventional plate fixation—a total of 5 per cent (5/105) This was due to metal fatigue secondary to instability caused by a bone defect opposite the plate

In Tables 6-8 the problems concerning infection and non union are presented It should be noted that the tables include three cases of above-knee amputation All these were severe Grade III fractures, in which a rather heroic attempt had been made to save the limb Two of the amputations were preceded by severe skin necrosis and one by deep infection

Table 6 Local complications following conservative treatment

	Closed fractures	Open fractures Grade I	Grade II	Grade III	Total	Total no of complications
No of patients	64	11	23	4	38	
Skin necrosis or superficial infection	1	3	8	2	13	14
Osteitis	0			1	1	1
Non union	4	2	5	1	8	12
Amputations	0			1	1	1
Total no	5	4	11	3	18	23

Table 7 Local complications following AO-compression osteosynthesis

	Closed fractures	Open fractures				Total no of complications
		Grade I	Grade II	Grade III	Total	
No of patients	37	16	7	4	27	
Skin necrosis or superficial infection	2	1	3	3	7	9
Deep infection	1	1	1	1	3	4
Osteitis	1				0	1
Amputation	0			2	2	2
Total no	4	2	4	6	9	13

Table 8 Local complications following conventional plate osteosynthesis

	Closed fractures	Open fractures				Total no of complications
		Grade I	Grade II	Grade III	Total	
No of patients	24	6	9	2	17	
Skin necrosis or superficial infection	3	1	3	2	6	9
Deep infection	0		1		1	1
Osteitis	1		1		1	2
Non union	2		4		4	6
Total no	6	1	8	2	11	17

Table 9 Results of follow up of 199 patients

	Conservative treatment	AO compression plates	Eggers/Lane plates
Patients treated	102	64	41
Patients followed up	100	61	38
Roentgenological findings			
Shortening ≥ 2 cm	5	0	0
Malalignment *	21	0	3
Clinical findings			
Ankle joint motion reduced ≥ 20°	7	3	0
Pain/weather sensitivity	7	3	2
Knee/ankle complaints	5	1	3
Re-fracture	1	5	0
Total no **	41	11	8

* Malalignment valgus/varus-angulation ≥ 8° and/or curvation ≥ 15°

** Some patients had more than one complaint or objective finding

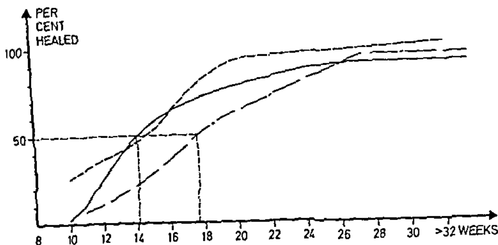


Figure 3 Healing time for transverse fractures

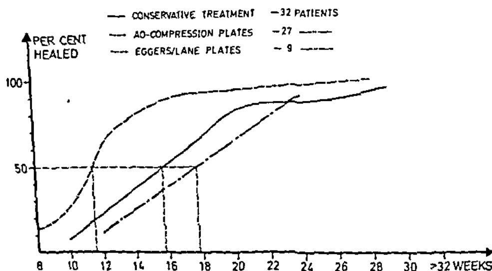


Figure 4 Healing time for oblique fractures

As seen in Table 6 nearly all skin necrosis and infections, following conservative treatment, occurred among the open fractures. Non union was encountered in 6 per cent (4/64) of closed fractures and in 21 per cent (8/38) of open fractures, but three of the latter were preceded by skin necrosis

The local complications following AO osteosynthesis are listed in Table 7 In 27

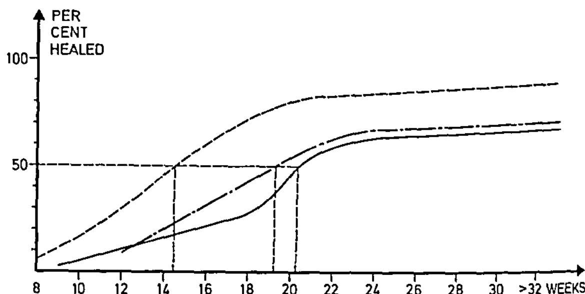


Figure 5 Healing time for comminuted fractures

open fractures there were two late deep infections, both of which healed after removal of the implant The third deep infection was the one mentioned leading to amputation, giving a total infection rate of 11 per cent (3/27) In 37 closed fractures the osteosynthesis was followed by one deep infection and one osteitis, both of which healed after 8 weeks and 13 months, respectively The infection rate for closed fractures was thus 5 per cent (2/37) Non-union was not encountered after AO compression osteosynthesis

In Table 8 it can be seen that local complications occurred in 11 out of 17 open fractures treated with conventional plates The infection rate was 12 per cent (2/17) and both healed The frequency of non-union was 24 per cent (4/17) In 24 closed fractures one late osteitis (4 per cent) was encountered, and two cases of non-union (8 per cent)

Fracture healing time The radiological criteria for union in conservative treatment and conventional plate osteosynthesis was solid, bony bridging of the fracture line by periosteal and endosteal callus Because of the so-called primary fracture healing obtained by the compression type of osteosynthesis it is difficult to define exactly when bony union has occurred We have considered these fractures as healed when the fracture line was invisible between the 8th and the 16th week provided there was no formation of irritation callus, *or* if irritation callus which had appeared earlier had been transformed into solid fixation callus As the different types of fractures do not involve similar problems of union we have illustrated the cumulative healing time for each group separately

The majority of the transverse fractures (Figure 3) were treated conservatively and healing was obtained for 50 per cent of the fractures within 14 weeks This was 3 weeks shorter than with conventional plate fixation In oblique fractures (Figure 4) the healing time for

50 per cent of the fractures was 4 weeks *shorter in the case of compression osteosynthesis compared with conservative treatment* The healing time for comminuted fractures (Figure 5) was markedly prolonged Fifty per cent were healed 6 weeks earlier in the AO group compared to the other two groups

Results of the follow up study are listed in Table 9 The roentgenological examination showed malalignment in 21 per cent (21/100) after conservative treatment and in 8 per cent (3/38) after conventional plate fixation The axis was restored in all cases after AO osteosynthesis

Pain was present in 12 patients, but in six cases this was only slight discomfort related to changes in the weather

Re fracture was observed in 1 per cent 1/100) after conservative treatment and in 11 per cent (5/46) after AO compression osteosynthesis The implant had been removed from 46 of the 61 patients attending the follow-up

A total of 30 per cent of the patients (60/199) presented with complaints or objective findings However, half of this number were patients treated *for comminuted* fractures

DISCUSSION

The difficult problem in the treatment of tibial fractures is whether to operate and risk infection, which can follow any form of operation Following *conservative* treatment of 61 closed fractures there were no severe infections, deep infection developed in 5 per cent of 61 patients treated with internal plate fixation Among 38 cases of open fracture there was one deep infection following conservative treatment, whereas 11 *per cent* of 14 patients treated by internal fixation *developed deep* infection These infection rates are similar to those reported in *other comparable series of* closed fractures (Infanger et al 1970, Karlström & Olerud 1974, Olerud & Karlström 1972, Rittmann et al 1970, *Ruedi et al* 1976) As for open fractures, however, our figures, like Rüedi et al's (1976), are lower than those presented by others (Bauer & *Hulth 1973, Smith 1974*) Primary open fracture treatment undertaken as an early acute procedure increased the risk of infection four-fold, but all these infections eventually healed and the fractures united, although the course was prolonged According to Aho & Hakkarainen (1974) and Smith (1974) the infection rates may be reduced considerably if the internal fixation is delayed for 2 3 weeks in open as well as in closed fractures

Concerning the *problems* of fracture union we found that transverse fractures united fairly rapidly with conservative treatment Oblique and comminuted fractures showed a prolonged healing course as has been pointed out by Nicoll (1974) Considerable time was gained, however, by the use of compression osteosynthesis, while with conventional plate osteosynthesis the healing time was the same as with conservative treatment There was no non-union after AO compression osteosynthesis, whereas with conservative treatment there was 6 per cent non-union in closed fractures and 21 per cent in open fractures Conventional plate fixa*tion involved* 8 per cent non union in *closed* fractures and 24 per cent in open fractures The literature contains only a few papers concerning this problem Smith (1974) reported 30 per cent with delayed union (≥ 26 weeks) *after primary* internal fixation of closed fractures and 48 per cent in open fractures, but *again* these figures were considerably reduced when using delayed osteosynthesis Rüedi et al (1976), *however,* found 4 per cent with delayed union in *closed fractures* and 13 per cent in open fractures applying the dynamic compression plate (DCP)

In our series 5 per cent implant failures

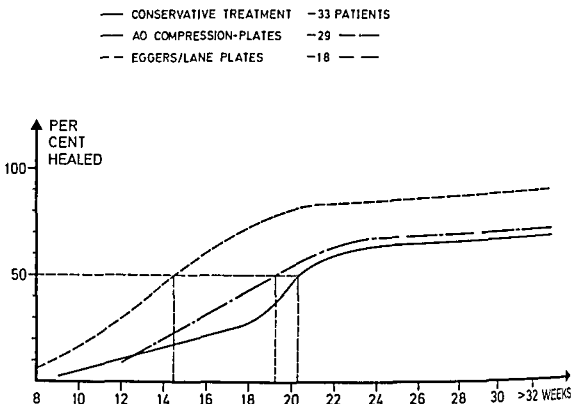


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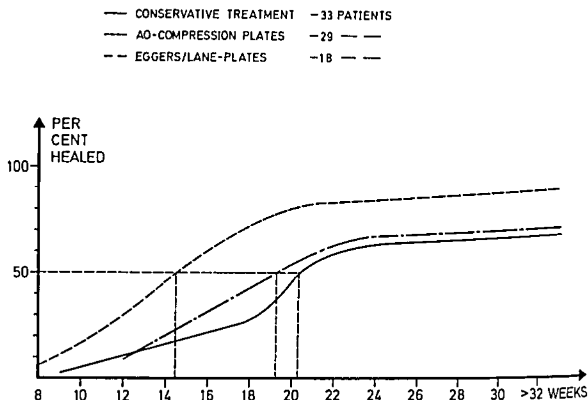


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Acta orthop scand 48 213 234 1977

PROCEEDINGS OF THE SCANDINAVIAN ORTHOPAEDIC SOCIETY

38th Assembly

Oslo Norway, June 1976

LUMBAR RADICULOGRAPHY WITH METRIZAMIDE ("AMIPAQUE")

I O Skalpe
Oslo Norway

Amipaque is a non ionic water soluble contrast medium for use in the subarachnoid space The toxicity is lower than for other commercially available contrast agents It can be injected without spinal anesthesia and gives good radiological contrast with an iodine concentration isotonic with the cerebral spinal fluid (170 mg I/ml) Serious acute complications have not been reported after more than 20 000 examinations Late sequelae such as adhesive arachnoiditis have not been seen The spasmogenic effect of the medium is very low and therefore the conus region can be included in the examination For the same reason functional myelography can be carried out in cases of suspected lumbar spinal stenosis

PROGNOSIS OF 158 SCIATICA PATIENTS

Antti Alho Erkki Karaharju Timo Paavilainen & Erkki Laasonen
Helsinki Finland

The patients were admitted to the hospital for symptoms and signs of sciatica Fifteen patients were operated on for cauda equina syndrome An elective disc operation was performed on 116 patients (minimum length of history 2 months average 4 6 months) A disc herniation was found in 108 operations (five false negative myelograms) No protrusion or other cause of nerve root compression was found in eight cases (four false positive myelograms) Compared with a series 10 years earlier the frequency of operation on two disc spaces had diminished from 30 per cent to 15 per cent and the frequency of unsatisfactory operative findings from 13 to 7 per cent. This we consider to be due to an improved myelographic technique and a better selection of patients for surgery Postoperatively the frequency of radiating pain was 58 per cent at 3 months 12 per cent at 6 months and 20 per cent at 12 months When the clinical radiological and operative findings were correlated with the results a positive correlation was found only between an adequate operative finding and a good result Conservative treatment was chosen in 27 cases where the clinical and radiological findings were not conclusive or when the patient refused to undergo an operation One year later there were no significant neurological differences between this group and the group which had undergone surgery In our earlier series we observed that the prognosis for 5 to 10 years did not depend on the operative result We conclude that in spite of 40 years' experience and intensive research including the cognizance of spinal stenosis and improvements in myelography the enigma of sciatica has only partially been solved

INDICATIONS FOR ACUTE SURGERY IN HERNIATED LUMBAR DISC

Georg Blikra
Oslo Norway

Recovery after compression of nervous structures depends on the acuteness degree and duration of the compression Hence patients with acute lower limb or urinary bladder paresis due to herniated lumbar disc are operated upon as soon as possible after emergency myelography

With earlier types of water soluble contrast media operation was postponed for 6 hours After the introduction of metrizamide surgery has been performed immediately after the X ray examination without adverse reactions

Several patients were admitted to our department at varying times after onset In a series of 107 patients with discogenic acute back 35 patients had surgery within 48 hours of onset and 26 in the next 48 hours In 31 patients there was a delay of more than one week.

All patients operated upon within 24 hours of onset and the majority operated within the

were seen in both types of plates, which agrees well with the findings of Olerud & Karlstrom (1972), but this figure is slightly higher than that stated by Ruedi et al (1976) The implant failures were however all due to metal fatigue because of instability caused by gaps in the fracture line opposite the plate The number of failures did not exceed our frequency of secondary displacements after conservative treatment

Malalignment leads to changes in the load distribution of the joint surface and late development of osteoarthritis may result One of the aims of osteosynthesis is therefore anatomical alignment Twenty-one per cent of the fractures were malaligned following conservative treatment and 8 per cent after conventional plate fixation After AO plate fixation anatomical alignment was achieved in all cases

Removal of the AO plates 1 year after application was followed by 11 per cent re-fractures This is about three times as many re-fractures as are stated by Olerud & Karlstrom (1972) and more than twenty times the figures of Ruedi et al (1976) Nearly all re-fractures were caused by new relevant traumas during sporting activities, such as soccer Three of the re-fractures occurred after 1–2 years, the remaining two occurred within 2 months of implant removal

In conclusion, we find that AO compression osteosynthesis is justified in the treatment of open tibial shaft fractures and is also a useful tool in cases of closed fractures, because of anatomical reduction, safe union and a shorter healing time in spite of an increased infection rate This disadvantage might be overcome by delayed osteosynthesis and by application of the plate on the lateral aspect of the tibial shaft covered by muscles As mentioned by others, however, (Bauer & Hulth 1973, Karlstrom & Olerud 1973, Wade 1970) the AO method may be a dangerous tool, and we feel that the use of this method must be restricted to *experienced orthopaedic surgeons* In our series of patients osteosynthesis with conventional Eggers or Lane plates was not superior to conservative treatment, which is still the method of choice whenever it is possible to retain reduction and good alignment

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Subjective symptoms were mild Common objective findings were scoliosis, kyphosis and back stiffness Changes in gait pattern were frequent Lasègue's test was positive at a few degrees Peripheral neurological signs were nearly always absent Our clinical material indicates there is a difference in symptomatology of lumbar disc herniation in children and adolescents as compared to adults

Mean follow up was 5 8 years Operative results were judged as excellent in 29 cases fair in [illegible] Scoliosis disappeared in all patients

FINDINGS AND RESULTS AFTER RE-OPERATION FOR LUMBAR DISC PROLAPSE

A Vebostad
Oslo Norway

Eighty five out of 104 patients re-operated upon for lumbar disc prolapse replied to a questionnaire Peroperative findings at re-operation were prolapse in the same disc in 28 patients prolapse in another disc in 16 patients prolapse and perineural scarring in 10 patients and perineural scarring and/or bony exerescences in 31 patients Results were stated as excellent by 31 patients good by 29 patients and poor by 25 patients True recurrences had very good results but if in addition marked perineural scarring was found a little less than 50 per cent benefitted from the re-operation The same was true if at operation only perineural scarring and or bony exerescences was found Myelography before re-operation gave positive or correct information in 69 per cent of cases Age and method of exposure did not seem to be of any significance The few backs with multiple operations had almost the same results as the others

PROLAPSED LUMBAR INTERVERTEBRAL DISC A 10 YEAR POSTOPERATIVE FOLLOW UP

Flemming F Madsen Erik Th Kjelbye & Finn Fuglsang
Sønderborg Denmark

A total of 174 patients were followed for variable periods up to 10 years and evaluated by questionnaire The operation was hemilaminectomy and evacuation of hernia and the intercorporal space No fixation was performed Mean age was 39 9 years and the female to male ratio was 1 2

At the 5 year follow-up (96 patients), 56 per cent had regained full working capacity and had no symptoms or only mild ones, 21 per cent had full working capacity but had some back symptoms and 27 per cent had a considerably lowered working capacity and/or major back complaints

The following factors correlated with a good prognosis age less than 40 years, no previous back complaints, short duration of symptoms at operation, preoperative work that was not back-straining, and high social position A positive correlation was found between high social position and no back strain at work Preoperative back strain at work had a minimal influence on the results, whereas social position was the most important factor

Two to ten years postoperatively, the condition of the patients had changed only to a slight degree, the number of patients deteriorating slightly exceeding the number of patients improving The postoperative symptoms of the individual patients were thus very stable after 2 years

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[illegible], Denmark

A follow-up study was made on 544 patients operated on, between 1962 and 1972, for herniated disc with removal of one or more discs 36 per cent were women 64 per cent were men The average age at the time of operation was 40 3 years The follow up period was from 4-14 years, in average 8 4 years

The history was acute in 25 per cent of the cases Work was a direct causative factor in 40 per cent of the cases

About half of the patients sought non medical treatment (quack doctors or chiropractors) before hospitalization, which consequently was delayed The results were better in the cases where the patients were operated upon within the first 2 months of the onset of symptoms, and they were better in younger than in older patients There was a correlation between the myelography and the findings at operation in 91 per cent of the cases There were only a few complications of myelographies and operations and no mortality 22 per cent were operated upon without delay 75 per cent of the cases gained relief from pains in the back and the legs The number with pareses was significantly reduced, but the number with disturbances of sensibility and reflexes was not reduced to the

next 24 hours, regained normal function The recovery rate then decreased steeply. Although all patients benefitted from surgery, incomplete recovery was the rule when there was a delay of more than one week

UNILATERAL AND BILATERAL ARCOTOMY FOR LUMBAR DISC PROLAPSE WITH UNILATERAL SCIATICA A FOLLOW-UP STUDY OF 156 PATIENTS

Rolf Hagen & Lars B Engesæter
Sandvika, Norway

The best surgical approach for lumbar disc lesions is still open to discussion, and few comparative reports have been published

Out of 250 patients operated upon for lumbar disc lesions between 1967–71, 156 were selected for review according to the following criteria a) at least 6 months preoperative history, b) unilateral sciatica, c) L 4–5 or L 5–S 1 disc lesion, d) no previous disc operation

Bilateral arcotomy was performed on 67 patients (Group I) and unilateral arcotomy on 89 (Group II) The follow-up was made 4–9 years postoperatively, and the patients in both groups were of similar age, sex and occupation They had similar histories, symptoms and signs, and myelographic findings No patient in Group I needed reoperation for recurrent prolapse whereas further surgery was required in four from Group II. At follow-up, 43 were symptom-free and 24 improved in Group I, while 30 were symptom free, 44 improved, 2 unchanged and 12 worse in Group II During the follow-up period 13 per cent of patients in Group I and 26 per cent in Group II had severe attacks of sciatica At the time of follow up 30 per cent in Group I and 51 per cent in Group II had low back pain

Bilateral arcotomy proved to be the operation of choice It caused no instability and did not predispose to the formation of adhesions opposite the lesion

COMPARISON OF THE RESULTS IN PATIENTS OPERATED UPON FOR RUPTURED LUMBAR DISCS WITH AND WITHOUT SPINAL FUSION

Nils Eie
Oslo, Norway

From 1967–1969 simple extirpation of the ruptured disc and excochleation of the inter vertebral space were performed in 191 patients, whereas a combined extirpation and lumbosacral fusion according to a modified Smith Petersen's method, was performed in 68 patients

Follow up studies in 1974–1975 showed that during the first half postoperative year the results were similar in the two groups with a satisfactory result in 89 per cent of the patients without spinal fusion and in 88 per cent of the patients with fusion Pain reappeared later in 26 per cent of the patients without fusion and in only 14 per cent of the patients with the combined operation Nineteen patients or 10 per cent of the patients without spinal fusion were re operated upon for recurrency or another ruptured disc One was operated upon for extra dural scar formation and adhesions, 11 had further courses in physiotherapy Recurrence of a disc protrusion in the area of a solid fusion has not been observed Two patients with fusion had reoperations for pseudarthrosis in the graft and one for a ruptured disc above a solid fusion

After reoperation and physiotherapy the difference in the results was less marked A satisfactory result was obtained in 76 per cent of the patients without fusion and in 85 per cent of the patients with the combined operation after an observation period of 6–7 years

Comparison of the present series with results in a previous investigation of 282 patients with spinal fusion also speaks in favour of the combined operation, particularly in younger individuals

ANTERIOR LUMBAR INTERBODY FUSION

K Harry Sorensen
Odense, Denmark

Ninety-eight patients were treated with fusion (extraperitoneal technique, grafts from the iliac crest) Indications were incapacitating low back pain caused by degeneration of the 4th/5th lumbar disc or spondylolisthesis 135 discs were degenerated, 114 were fused There were no complications in 75 per cent, 11 had thrombophlebitis two fatal pulmonary embolism four slight infarctions and three severe atelectasis

At follow up, 3–8 years later, the fusions were solid in 91 per cent and after re operation in 94 per cent Healing was not achieved in 21 per cent of the patients with spondylolisthesis Seventy-three per cent felt better or cured Thirty-one patients had constant pain (21 somatic explanation) Sixty per cent of the patients operated upon after the age of 45 received disablement pension

The most suitable patients for the operation are those who are motivated, energetic, non neurotic and not adipose

LUMBAR INTERVERTEBRAL DISC HERNIATION IN CHILDREN AND ADOLESCENTS

H Russworm F Ronglan & I Bjerkreim
Oslo Norway

During the period 1965–1975 35 patients aged 10–18 years were operated upon for lumbar disc

herniation There were 19 girls and 16 boys The duration of symptoms was on average 20 months before diagnosis was made Only 10 patients were referred to the hospital under the diagnosis of ischialgia A previous trauma was found in nine cases

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About half of the patients sought non medical treatment (quack doctors or chiropractors) before hospitalization which consequently was delayed. The results were better in the cases where the patients were operated upon within the first 2 months of the onset of symptoms and they were better in younger than in older patients There was a correlation between the myelography and the findings at operation in 91 per cent of the cases There were only a few complications of myelographies and operations and no mortality 22 per cent were operated upon without delay 75 per cent of the cases gained relief from pains in the back and the legs. The number with pareses was significantly reduced but the number with disturbances of sensibility and reflexes was not reduced to the

next 24 hours regained normal function The recovery rate then decreased steeply Although all patients benefitted from surgery, incomplete recovery was the rule when there was a delay of more than one week

UNILATERAL AND BILATERAL ARCOTOMY FOR LUMBAR DISC PROLAPSE WITH UNILATERAL SCIATICA A FOLLOW UP STUDY OF 156 PATIENTS

Rolf Hagen & Lars B Engesæter
Sandvika Norway

The best surgical approach for lumbar disc lesions is still open to discussion and few comparative reports have been published

Out of 250 patients operated upon for lumbar disc lesions between 1967 71, 156 were selected for review according to the following criteria a) at least 6 months preoperative history b) unilateral sciatica c) L 4 5 or L 5 S 1 disc lesion d) no previous disc operation

Bilateral arcotomy was performed on 67 patients (Group I) and unilateral arcotomy on 89 (Group II) The follow up was made 4 9 years postoperatively, and the patients in both groups were of similar age sex and occupation They had similar histories symptoms and signs and myelographic findings No patient in Group I needed reoperation for recurrent prolapse whereas further surgery was required in four from Group II At follow up 43 were symptom free and 24 improved in Group I while 30 were symptom free 44 improved 2 unchanged and 12 worse in Group II During the follow up period 13 per cent of patients in Group I and 26 per cent in Group II had severe attacks of sciatica At the time of follow up 30 per cent in Group I and 51 per cent in Group II had low back pain

Bilateral arcotomy proved to be the operation of choice It caused no instability and did not predispose to the formation of adhesions opposite the lesion

COMPARISON OF THE RESULTS IN PATIENTS OPERATED UPON FOR RUPTURED LUMBAR DISCS WITH AND WITHOUT SPINAL FUSION

Nils Eie
Oslo Norway

From 1967 1969 simple extirpation of the ruptured disc and excochleation of the inter vertebral space were performed in 191 patients whereas a combined extirpation and lumbosacral fusion according to a modified Smith Petersen s method was performed in 78 patients

Follow up studies in 1974 1975 showed that during the first half postoperative year the results were similar in the two groups with a satisfactory result in 89 per cent of the patients without spinal fusion and in 88 per cent of the patients with fusion Pain reappeared later in 26 per cent of the patients without fusion and in only 14 per cent of the patients with the combined operation Nineteen patients or 10 per cent of the patients without spinal fusion were re operated upon for recurrency or another ruptured disc One was operated upon for extra dural scar formation and adhesions 11 had further courses in physiotherapy Recurrence of a disc protrusion in the area of a solid fusion has not been observed Two patients with fusion had reoperations for pseudarthrosis in the graft and one for a ruptured disc above a solid fusion

After reoperation and physiotherapy the difference in the results was less marked A satisfactory result was obtained in 76 per cent of the patients without fusion and in 85 per cent of the patients with the combined operation after an observation period of 6–7 years

Comparison of the present series with results in a previous investigation of 282 patients with spinal fusion also speaks in favour of the combined operation particularly in younger individuals

ANTERIOR LUMBAR INTERBODY FUSION

K Harry Sorensen
Odense Denmark

Ninety eight patients were treated with fusion (extraperitoneal technique grafts from the iliac crest) Indications were incapacitating low back pain caused by degeneration of the 4th/5th lumbar disc or spondylolisthesis 135 discs were degenerated 114 were fused There were no complications in 75 per cent 11 had thrombophlebitis two fatal pulmonary embolism four slight infarctions and three severe atelectasis

At follow up 3–8 years later the fusions were solid in 91 per cent and after re operation in 94 per cent Healing was not achieved in 21 per cent of the patients with spondylolisthesis Seventy three per cent felt better or cured Thirty one patients had constant pain (21 somatic explanation) Sixty per cent of the patients operated upon after the age of 45 received disablement pension

The most suitable patients for the operation are those who are motivated energetic non neurotic and not adipose

LUMBAR INTERVERTEBRAL DISC HERNIATION IN CHILDREN AND ADOLESCENTS

H Russworm I Ronglan & I Bjerkreim
Oslo Norway

During the period 1965 1975 35 patients aged 10 18 years were operated upon for lumbar disc

herniation There were 19 girls and 16 boys The duration of symptoms was on average 20 months before diagnosis was made Only 10 patients were referred to the hospital under the diagnosis of ischialgia A previous trauma was found in nine cases

Subjective symptoms were mild Common objective findings were scoliosis kyphosis and back stiffness Changes in gait pattern were frequent. Lasègue s test was positive at a few degrees Peripheral neurological signs were nearly always absent Our clinical material indicates there is a difference in symptomatology of lumbar disc herniation in children and adolescents as compared to adults

Mean follow up was 5 8 years Operative results were judged as excellent in 29 cases fair in 6 Scoliosis disappeared in all patients

FINDINGS AND RESULTS AFTER RE OPERATION FOR LUMBAR DISC PROLAPSE

A Vebostad
Oslo Norway

Eighty five out of 104 patients re-operated upon for lumbar disc prolapse replied to a questionnaire Peroperative findings at re-operation were prolapse in the same disc in 28 patients prolapse in another disc in 16 patients prolapse and perineural scarring in 10 patients and perineural scarring and or bony excrescences in 31 patients Results were stated as excellent by 31 patients good by 29 patients and poor by 25 patients True recurrences had very good results but if in addition marked perineural scarring was found a little less than 50 per cent benefited from the re-operation The same was true if at operation only perineural scarring and or bony excrescences was found Myelography before re-operation gave positive or correct information in 68 per cent of cases Age and method of exposure did not seem to be of any significance The few backs with multiple operations had almost the same results as the others

PROLAPSED LUMBAR INTERVERTEBRAL DISC A 10 YEAR POSTOPERATIVE FOLLOW UP

Flemming F Malsen Erik Th Kjølbye & Finn Fuglsang
Sønderborg Denmark

A total of 174 patients were followed for variable periods up to 10 years and evaluated by questionnaire The operation was hemilaminectomy and evacuation of hernia and the intercorporal space No fixation was performed. Mean age was 39 9 years and the female to male ratio was 1 2

At the 5-year follow up (96 patients) 56 per cent had regained full working capacity and had no symptoms or only mild ones 21 per cent had full working capacity but had some back symptoms and 27 per cent had a considerably lowered working capacity and/or major back complaints

The following factors correlated with a good prognosis age less than 40 years no previous back complaints short duration of symptoms at operation preoperative work that was not back straining, and high social position A positive correlation was found between high social position and no back strain at work Preoperative back strain at work had a minimal influence on the results whereas social position was the most important factor

Two to ten years postoperatively the condition of the patients had changed only to a slight degree the number of patients deteriorating slightly exceeding the number of patients improving The postoperative symptoms of the individual patients were thus very stable after 2 years

FINAL RESULT STUDY OF 544 PATIENTS OPERATED UPON FOR HERNIATED INTERVERTEBRAL LUMBAR DISC

J Damholt & P Olsen
Holstebro Denmark

A follow up study was made on 544 patients operated on between 1962 and 1972 for herniated disc with removal of one or more discs 36 per cent were women 64 per cent were men The average age at the time of operation was 40.3 years The follow up period was from 4 14 years in average 8 4 years

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months because of lack of improvement. The remaining six do not differ significantly from the operated cases.

TREATMENT OF POSTOPERATIVE DISCITIS WITH ANTICOAGULATION

B. Rangart, P. Helin, N. Jarlov & P. Ahlgren
Copenhagen, Denmark

An account is given of 15 patients with postoperative discitis who were treated with anticoagulants, Indometacin and bed rest. This treatment had the result that patients confined to bed were relieved of their symptoms after about 10 days treatment and later could be mobilized. With the aid of a lumbo-sacral support they could continue treatment as outpatients. The effect of anticoagulants suggested that a localized hypercoagulability might play a certain role, either as a pathogenetic or a pathophysiological factor. In the present series the clinical manifestations were: 1) constant piercing local pain in the back, 2) tenderness to percussion at the sites of the affected vertebrae, 3) diffuse pain localized to both lower extremities and tenderness to palpation at the sides of the long saphenous vein and the femoral triangle (Scarpa's triangle), 4) acute abdominal pain occasionally combined with paresis of the urinary bladder. The clinical symptoms occurred about weeks before the vertebral lesions were roentgenologically demonstrable. Laboratory tests early in the course of the disease failed to provide data by which the diagnosis could be verified.

RESECTION OF PROCESSUS SPINOSUS IN 102 PATIENTS WITH CHRONIC LOW BACK PAIN

B. Lund & P. Ramsing
Århus, Denmark

Degenerative changes in the lumbar interspinal ligaments and processi spinosi may be a cause of low back pain. During the period 1963-1975 in 106 patients suffering from chronic low back pain, a localized tenderness was demonstrated between two lumbar processi spinosi. X-ray showed kissing spine and degeneration of one or more lumbar discs. The low back pain disappeared for 2–4 hours following repeated injection of 3 ml local anaesthetic into the interspinal ligaments and the operation was performed with resection of the lumbar processus spinosus and the interspinal ligaments. The duration of the operation was 15–30 minutes and the patients were discharged on the fifth postoperative day.

The average age of the patients was 4? years and the duration of symptoms averaged 9½ years. In a follow up of 102 patients, 39 females and 63 males, 9 months to 10 years after the operation, 42 patients were improved with disappearance or relief of symptoms. Forty-two patients were unchanged and in 18 patients the pain was aggravated. Several patients in the last two groups, however, had relief of symptoms a few months after the operation.

MUSCULAR ATROPHY IN THE PROLAPSED LUMBAR INTERVERTEBRAL DISC

K. Haug
Gjøvik, Norway

In 30 per cent of sciatica patients differences in circumference, usually 1 cm, can be measured in the lower extremities. In a leg segment 10 cm high, considered as a cone right truncated, 1 cm difference in circumference will represent a volume reduction of 60-90 ml. The principle of volume measurement is to "transfer" a leg segment to a cylinder of the same height. Then the segment volume equals the cylinder volume minus the rest volume.

Comparable segments are defined by two parallel planes vertical to the leg axis at a fixed reciprocal distance and at the same height over the base of the foot. For measurements one rack for the thigh and one for the calf and adequate cylinders are needed. The leg encircled by the cylinder is placed in the rack with a levelled plate of foam rubber under the cylinder. Thin plastic foil covers the cavity, which is filled up with liquid. This liquid is then transferred to the other leg under same measuring conditions. The reduction of volume in one segment equals the difference between the two rest volumes. Volume differences are due to muscular atrophy, which may have local causes as well as being a result of affections of the lower motor neurones of various aetiologies. It indicates destruction of these cells. When a reduction of volume is measured during a disc protrusion syndrome the symptom will be of great significance.

FACTORS INFLUENCING WORKING CAPACITY FOLLOWING DISC SURGERY

T. Suren
Borås, Sweden

Results of lumbar disc surgery in terms of total postoperative disability time and return to work were recorded. The analysis was based on a total of 36? patients. The number of recurrences and the percentage of disablement pensions were directly related to the length of the observation time.

A short interval between the onset of leg pain and the time of the operation was an important

same degree The factor which most inhibited work was pain in the back and legs whereas paresis hardly ever caused inability to work

1000 MYELOGRAPHIES WITH MEGLUMINE IOTHALAMAT (CONRAY MEGLUMIN 282)

Lars Anda
Sandnes Norway

One thousand myelographies were performed between 1969 and 1974 A total of 934 patients were examined (627 men and 307 women), 66 patients twice or more Most of the patients (306) were 40 49 years nine were 10–19 and five were 70–79 years old

The myelographies showed prolapses in 404 cases Among those 376 were operated on and in 345 cases true prolapses were found whereas protrusion or degeneration of the disc was found in 27 cases Roentgenologically there was a good correlation in 337 cases fairly good in 26 cases and not so good in 13 cases

In 19 of the myelographies regions of poor contrast or total blockage were found Sixteen of these were operated on and prolapses were found in 11 cases One patient had a malignant tumour and two had lumbar stenosis Roentgenologically there was good correlation in 14 cases it was fairly good in one case and not so good in one case

In 315 cases only minor changes such as shortening of the root sleeves were found A total of 153 patients were operated on 55 with prolapses and 97 with protrusion or degeneration of the disc Roentgenological examination showed a good correlation in 97 cases fairly good in 97 cases and not so good in 10 cases

In 262 myelographies there were negative results Twenty six of them were operated on and in six cases prolapses were found Protrusions were found in two cases and negative results in 18 cases Roentgenologically there was a good correlation in 18 cases fairly good in two cases and not so good in six cases

Cramp was registered in four cases In four other cases jerks of the lower extremities were experienced Fifteen suffered from headache and partial collapse was registered in five cases Cramp and jerks were immediately relieved by intravenous injection of Diazepam (Valium) possibly repeated a few times

EFFECTS OF CHYMOPAPAIN ON NERVE TISSUE

B Rydevik P I Brånemark C Nordborg
W G McLean J Sjöstrand & M Fogelberg
Goteborg Sweden

Chymopapain chemonucleolysis as treatment for *intervertebral disc disease has been widely* used during the last few years The literature on the subject reports differing opinions concerning indications results complications and the possible mechanism by which chymopapain relieves low back pain and sciatica

Chymopapain which is injected into an intervertebral disc may leak out to the surrounding tissues and reach neural elements e g local sensory nerves and a nerve root The effects of chymopapain on such peripheral nerve tissue have been investigated in the present study The tibial nerves of 63 rabbits were used for the experimental model and the effects of 1 ml of 0 4 per cent chymopapain were compared with those of 1 ml of isotonic saline The following parameters were investigated

1 Intraneural microcirculation and permeability of the perineurial sheath (fluorescent microscopy)
2 Axonal transport of proteins (radioactive protein determination)
3 Nerve function (neurophysiology)
4 Nerve fibre and intraneural connective tissue reactions (neurohistology)

The results showed that chymopapain had no acute effects on impulse conductivity or axonal transport The enzyme induced however intraneural oedema formation by increasing the permeability of the intraneural microvessels and the perineurial sheath The long term effects were nerve fibre degeneration and intraneural fibrosis formation leading to impaired nerve function

CHYMOPAPAIN INJECTION FOR DISC HERNIA —PRELIMINARY RESULTS OF A CONTROLLED STUDY

A Nachemson A Ejeskär, P Herberts &
E Lysell
Goteborg Sweden

Although chymopapain injection treatment for disc hernias has recently been stopped in the USA it is still in use in Europe and Canada In order to compare the results of *chymopapain* injection versus conventional disc surgery a controlled study on patients with typical L5 syndrome and a positive water soluble contrast myelography was performed

Preliminary results of this strictly controlled study (half of the patients were operated upon and the other half received chymopapain intradiscally) show that injection treatment in this series of 18 patients (9 + 9) followed up for at least half a year by an independent examiner appears to give some immediate advantages in the form of a shorter stay in hospital and a shorter sick leave period but it does not give as good end results *as surgery* Thus three out of nine cases were reoperated upon within 2

months because of lack of improvement The remaining six do not differ significantly from the operated cases

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Comparable segments are defined by two parallel planes vertical to the leg axis at a fixed reciprocal distance and at the same height over *the base of the foot* For measurements, one rack for the thigh and one for the calf and adequate cylinders are needed The leg encircled by the cylinder is placed in the rack with a levelled plate of foam rubber under the cylinder Thin plastic foil covers the cavity which is filled up with liquid This liquid is then trans ferred to the other leg under same measuring conditions The reduction of volume in one seg ment equals the difference between the two rest volumes Volume differences are due to muscular atrophy which may have local causes as well as being a result of affections of the lower motor neurones of various aetiologies. *It indicates* destruction of these cells When a reduction of volume is measured during a disc protrusion syndrome the symptom will be of great signif icance

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I Surin
Borås Sweden

Results of lumbar disc surgery in terms of total postoperative disability time and return to work were recorded The analysis was based on a total of 366 patients The number of recur rences and the percentage of disablement pen sions were directly related to the length of the observation time

A short interval between the onset of leg pain and the time of the operation was an important

same degree The factor which most inhibited work was pain in the back and legs, whereas paresis hardly ever caused inability to work

1000 MYELOGRAPHIES WITH MEGLUMINE IOTHALAMAT (CONRAY MEGLUMIN 282)

Lars Anda
Sandnes, Norway

One thousand myelographies were performed between 1969 and 1974 A total of 934 patients were examined (627 men and 307 women), 66 patients twice or more Most of the patients (306) were 40–49 years, nine were 10–19 and five were 70–79 years old

The myelographies showed prolapses in 404 cases Among those 376 were operated on and in 345 cases true prolapses were found, whereas protrusion or degeneration of the disc was found in 27 cases Roentgenologically there was a good correlation in 337 cases, fairly good in 26 cases and not so good in 13 cases

In 19 of the myelographies regions of poor contrast or total blockage were found Sixteen of these were operated on, and prolapses were found in 11 cases One patient had a malignant tumour and two had lumbar stenosis Roentgenologically there was good correlation in 14 cases, it was fairly good in one case and not so good in one case

In 315 cases only minor changes, such as shortening of the root sleeves, were found A total of 153 patients were operated on, 55 with prolapses and 97 with protrusion or degeneration of the disc Roentgenological examination showed a good correlation in 97 cases, fairly good in 97 cases and not so good in 10 cases

In 262 myelographies there were negative results Twenty-six of them were operated on, and in six cases prolapses were found Protrusions were found in two cases and negative results in 18 cases Roentgenologically there was a good correlation in 18 cases, fairly good in two cases and not so good in six cases

Cramp was registered in four cases In four other cases jerks of the lower extremities were experienced Fifteen suffered from headache, and partial collapse was registered in five cases Cramp and jerks were immediately relieved by intravenous injection of Diazepam (Valium) possibly repeated a few times

EFFECTS OF CHYMOPAPAIN ON NERVE TISSUE

B Rydevik, P-I Brånemark, C Nordborg W G McLean, J Sjöstrand & M Logelberg
Goteborg, Sweden

Chymopapain chemonucleolysis as treatment for intervertebral disc disease has been widely used during the last few years The literature on the subject reports differing opinions concerning indications, results, complications and the possible mechanism by which chymopapain relieves low back pain and sciatica

Chymopapain which is injected into an intervertebral disc may leak out to the surrounding tissues and reach neural elements, e g local sensory nerves and a nerve root The effects of chymopapain on such peripheral nerve tissue have been investigated in the present study The tibial nerves of 63 rabbits were used for the experimental model and the effects of 1 ml of 0 4 per cent chymopapain were compared with those of 1 ml of isotonic saline The following parameters were investigated:

1 Intraneural microcirculation and permeability of the perineurial sheath (fluorescent microscopy)
2 Axonal transport of proteins (radioactive protein determination)
3 Nerve function (neurophysiology)
4 Nerve fibre and intraneural connective tissue reactions (neurohistology)

The results showed that chymopapain had no acute effects on impulse conductivity or axonal transport The enzyme induced, however intraneural oedema formation by increasing the permeability of the intraneural microvessels and the perineurial sheath The long term effects were nerve fibre degeneration and intraneural fibrosis formation, leading to impaired nerve function

CHYMOPAPAIN INJECTION FOR DISC HERNIA —PRELIMINARY RESULTS OF A CONTROLLED STUDY

A Nachemson A Kjesldr, P Herberts & I Fysell
Goteborg, Sweden

Although chymopapain injection treatment for disc hernias has recently been stopped in the USA it is still in use in Europe and Canada In order to compare the results of chymopapain injection versus conventional disc surgery a controlled study on patients with typical L5 syndrome and a positive water soluble contrast myelography was performed

Preliminary results of this strictly controlled study (half of the patients were operated upon and the other half received chymopapain intradiscally) show that injection treatment in this series of 18 patients (9 + 9) followed up for at least half a year by an independent examiner, appears to give some immediate advantages in the form of a shorter stay in hospital and a shorter sick leave period but it does not give as good end results as surgery Thus three out of nine cases were reoperated upon within 2

achieved in 55 patients (60 4 per cent) satisfactory in 23 (24 1 per cent) and unsatisfactory in 13 (15 5 per cent) Posterolateral fusion seems to be preferable to posterior fusion

A ROENTGEN STEREOPHOTOGRAMMETRIC METHOD FOR STUDYING THE HEALING OF FUSIONS OF THE SPINE

St g Willner Tord Olsson & Göran Selvik
Malmo and Lund Sweden

A roentgen stereophotogrammetric method is described for studying the movements between separate segments of the vertebrae following fusion operations This method determines the rotations and translations about the X Y and Z axes with great accuracy Rotations down to 0 1° and translations down to 0 1 mm are estimated Three indicators are inserted in each vertebra Two exposures of the patient are obtained simultaneously from two roentgen tubes on one film A calibration cage is also double exposed on the same film In the walls of the cage indicators with known three-dimensional positions are inserted The measured two dimensional positions on the film of the indicators in the cage and the object are then treated by data processing as described by Selvik 1974) The coordinates of the indicators of the spine are then estimated in a Cartesian coordinate system bound to the calibration cage and the general displacement of each vertebra in relation to another is described

With this method the decreased movements in a fusion mass (the healing of a fusion operation) can be followed and defective healing pseudarthrosis) will thus be detected After a scoliosis operation the three dimensional loss of correction can also be described

Two cases with a fusion operation—one with a spondylolisthesis L5–S1 and the other with an idiopathic scoliosis—were demonstrated

CAN SKELETAL MUSCLE FIBRE ATROPHY IN A CAST BE PREVENTED BY *EXERCISE?*

Bengt Saltin
Copenhagen Denmark

Skeletal muscle fibres can be divided into two main types designated Type I (red or slow) and Type II white or fast) fibres The latter group can be further divided into A and B types where the II B fibres are the *typical* white fibres with a very low oxidative potential and poor endurance Human skeletal muscles are a mixture of fibres with an average distribution of 50 per cent Type I 34 per cent Type II A and 16 per cent Type II B The relative distribution of fibres varies markedly between individuals but is much more consistent in muscles from the same person No definite proof exists to show that a conversion of Type I to Type II fibres may occur with inactivity or activity but the size of the fibres as well as their metabolic potential varies in relation to the use or disuse of the fibres

Five to six weeks in a cast results in a significant reduction in size of both fibre types and in oxidative and glycolytic enzyme activity These changes may explain the reduced strength and endurance of the muscles found after an extremity has been in a cast The performance of maximal isometric contractions of the muscles while in a cast reduces the hypotrophy of Type II fibres which appear to be the fibre which is recruited predominantly in this type of contraction In order to activate the Type I fibres and train their oxidative potential light contractions performed over a period of 15–30 minutes are needed Combining these two forms of exercises the size of the fibres and their metabolic capacity will still be reduced after having the extremity in a cast but only to a very minor degree The advantage is that the recovery period can be shortened and normal activities and athletic training can be resumed earlier

LIGAMENT INJURIES OF THE KNEE JOINT—THE DIAGNOSIS AND TREATMENT

Jan Gillquist Sten Otto Liljedahl
Gunnar Hagberg & Nils Oretorp
Linkoping Sweden

The difficulties encountered in the diagnosis of knee injuries are well known Liljedahl et al have shown that the uncertainty of clinical examination can be reduced by examination under anaesthesia or arthrography Combined injuries present more difficulties than single

5 mm Storz arthroscope introduced into the joint through the patellar tendon (Gillquist & Hagberg 1976) The joint is flushed with sterile water by an infusion pump The water leaves the joint through a specially made arthroscopy cannula" (Stille Werner Stockholm Sweden) For the inspection of the posteromedial and the posterolateral compartments a 70° telescope is used whereas the *rest of the joint* is examined through the normal 30° telescope We have examined 800 injured knees by this method Of special interest is a study of 84 examinations in the acute stage (Gillquist Hagberg Oretorp to be published) Haemarthrosis was usually due to rupture of the anterior cruciate ligament in combination with other injuries Locking of the knee joint was an unreliable *sign of a torn*

prognostic factor Patients with negative neurological and myelographic findings were poor candidates for disc surgery

Fifty-seven per cent of the patients continued the same work, 24 per cent of the patients changed their work, 24 per cent received disablement pensions

PSYCHIC AND SOCIAL FACTORS IN THE TREATMENT OF PATIENTS WITH LUMBAR DISC PROLAPSE

A Halttunen & I E Laurent
Helsinki, Finland

This series consists of 54 patients suffering from low back pain and sciatica Of these, 39 were operated on, ten received physiotherapy, and five manipulation of the back under anaesthesia The patients were examined by a clinical psychologist before treatment and 6 and 12 months after treatment in order to create a model to predict the results of treatment Medical factors (result of treatment), social factors (ability to work), and psychic factors (the patient's mental health and his opinion of the result of treatment) were taken into account The results of treatment could be predicted by taking six factors into account in 55 per cent of the cases, and the ability to return to work, also using six factors, could be predicted in 68 per cent of the cases

The following medical factors indicated a good result no previous operations on the back, typical signs of a protruded disc, a short period of pain and of sick leave before treatment, and operative treatment

The most important social factors were as follows intellectual work or labour where the *working position could be changed, sick leave* of less than 3 months education more than that of elementary school, operation as a semi-private patient, and age under 30 or over 40

The most important psychic factors were the patient considered it absolutely necessary to return to work, keen intelligence, no visits to the doctor for trivialities, hardly any psychic or psychosomatic signs, and the patient was self-reliant, his behaviour open, and his motivation to work good even overemphasized

The most important factors in the rehabilitation of patients with low back pain and sciatica are the duration of the disease and the influence of the disease on the ability to work and on the existing possibilities for the patient

In a chronic disease the process of rehabilitation is a psycho-socio economic problem rather than a medical one An examination by a clinical psychologist may help the orthopaedic surgeon to avoid unnecessary operations on the back

THE SOCIAL STATE OF 615 PATIENTS BEFORE AND AFTER OPERATION FOR HERNIATED LUMBAR DISC

P Ottsen & V Damholt
Holstebro, Denmark

A total of 615 patients were operated upon for herniated lumbar disc 544 of these patients (92 per cent of the patients alive) were seen during a follow-up investigation which included a clinical examination and an interview concerning the social and economic consequences of their disease The mean period of observation was 9 years

A majority of the patients operated upon for lumbar disc prolapse had a low level of education and did hard physical work Eighty per cent of the patients resumed work after the operation 286 patients had changed their job at the follow up investigation, 54 9 per cent of these because of the disease Ninety-three patients were referred to centres for rehabilitation 47 3 per cent with success Two thirds of the patients who did not succeed in rehabilitation were over the age of 45 years

OPERATIVE TREATMENT OF *SPONDYLOLISTHESIS IN YOUNG PATIENTS*

I F Laurent & K Österman
Helsinki, Finland

A series of 91 patients under 20 years of age with lytic lumbar spondylolisthesis, treated operatively at the Orthopaedic Hospital of the Invalid Foundation, Helsinki, are presented Sixty-six patients (73 per cent) showed a displacement of more than 30 per cent on admission If the displacement exceeds 30 per cent *it often progresses to a total* or subtotal olisthesis, fusion should be performed before the slipping exceeds one third of the length of the vertebral body Posterior fusion was performed in 78 patients (87 5 per cent) In connection with fusion, laminectomy was performed in 13 patients Ventral fusion was performed in three patients and posterolateral fusion in 10 cases of these four as a second operation Laminectomy only was carried out in four patients three of them having a total olisthesis and one a massive disc herniation Laminectomy without fusion should be performed only in exceptional cases in young patients

Non union or uncertain union after the first operation occurred in 17 patients (19 5 *per cent)* Of these, 13 patients were reoperated upon Two patients had two reoperations The degree of slipping at the operation did not influence the results A progression of displacement was observed in 14 patients in spite of dorsal fusion The final results show that good results were

patients had resumed their sporting activities completely whereas eight had decreased their activity as far as track training was concerned Two patients had given up their sport although they gave reasons other than lower limb pain for this decision.

RUPTURE OF THE TENDO ACHILLIS A FOLLOW UP INCLUDING MEASUREMENT OF THE POWER OF PLANTAR FLEXION

N B Termansen & V Damholt
Odense Denmark

During the period 1970–1974 71 patients were treated for subcutaneous ruptures of the tendo Achillis at the Orthopaedic Department Odense University Hospital, Denmark. Sport was the reason for 81 8 per cent of the lesions Operative treatment comprised suture and plastic repair with a strip of the tendon of the gastrocnemius muscle in 38 patients suture only in 16 patients and non operative treatment with plaster of Paris in 12 patients At follow up from 14–77 months after the injury 66 patients or 97 1 per cent of all surviving patients were re examined Complications were most common in patients treated surgically with plastic repair Significant complaints were found in 12 1 per cent of the patients while 59 1 per cent had no symptoms at all The circumference of the calf was less in the affected than in the unaffected limbs ($P < 0\,001$) The power of plantar flexion averaged 10 1 per cent less in the affected than in the unaffected limbs ($P < 0\,001$) but only slight positive correlation was found between circumference and power ($r = 0\,32$) In two patients only the working capacity was reduced because of the injury but seven out of 54 patients had abandoned sport because of the injury and 10 for some other reason The power of plantar flexion correlated in most cases with the ability to return to sport

PROGNOSTICATED AND ACTUAL DURATION OF INCAPACITY AFTER SPORTS INJURIES

H Victor Nielsen & E Kragh Petersen
Odense Denmark

A total of 721 emergency room outpatients with regular work aged 15–65 years were followed up and the period of incapacity after their accident was studied Eighty patients were hurt while playing sport The casualty officer estimated the expected number of lost days (prognosticated incapacity) By letter the patients gave information as to what date they started work again (actual incapacity) Eighty nine per cent replied

A graphic picture of the prognosticated and the actual incapacity period showed two almost parallel curves indicating a constant and therefore acceptable prognostication In the total material there was an underestimation of the time of incapacity The ratio between prognosticated and actual incapacity following sports injuries was 1 27 Sports injuries resulted in a longer period of incapacity than other injury groups with identical diagnoses (e g., industrial accidents) The mean prognosticated incapacity period for sports injuries amounted to 10 2 days —the actual was 12 9 days The difference between the two figures was reduced in cases of overestimation of the incapacity The average error of judgment for sports injuries was 7 days and it was a little less for light traffic and industrial accidents

Prognosticated time of incapacity in number of days was a simple means of measuring the severity of the lesions, and in our material it was a considerably better measuring devise than the D diagnosis and the E code

RADIOGRAPHIC MEASUREMENT OF THE STABILITY OF THE KNEE JOINT IN INJURIES TO THE LIGAMENTS BASED ON A MATERIAL OF ATHLETES

Klaus Jacobsen
Gentofte Denmark

The measuring method consisted of mechanical action upon the joint in different directions by well defined hydraulic forces, using a special apparatus the gonylaxometer while radiographs were exposed Looseness was measured on the film Normal values were arrived at by studying a material of 50 subjects The 97½ per cent upper limits for normal knees were 2 mm for medial and lateral collateral looseness and 3 mm for anterior as well as posterior looseness (measured as the difference between the sound and the traumatized knee) The pathological material comprised 153 knee lesions the majority in athletes The stress radiographic findings were compared with the operative findings and with the primary clinical evaluation and the

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meniscus the diagnosis being correct in only half the cases In a small series we have also removed free bodies percutaneously under direct inspection through the arthroscope

MINOR SPORTS INJURIES A 7 YEAR MATERIAL

S Nilsson & A Roaas
Oslo and Sandvika Norway

At a clinic for sports injuries in Oslo 2729 athletic injuries have been treated over the past 7 years The injuries were mostly minor, interfering with the athletes' ability to train or compete Almost 50 per cent occurred in soccer which reflects that soccer is the most popular sport in Norway More surprisingly injuries in runners came second Eighty per cent of these injuries were over use or stress injuries In contact sports 80 per cent were acute traumatic injuries Whereas the acute injuries differed little from similar injuries suffered in non athletes 74 per cent of the stress injuries were found in four regions the achilles tendon the lateral femoral condyle the patellar tendon and the medial or lateral aspects of the tibia All responded well to treatment which consisted of physical therapy altering or lowering the training load and taping An increasing number of the over use injuries were found in adolescents probably reflecting a tendency to treat children as miniature adults thus subjecting them to training loads exceeding the tolerance limits of their tendons and tendon insertions

A PROSPECTIVE STUDY OF HORSE RIDING ACCIDENTS

H R Lie & U Lucht
Arhus Denmark

During 1975 a total of 203 patients were treated at the Arhus County Hospital for injuries sustained after horse riding accidents Seventy four per cent were women and 26 per cent men The average age was 18 7 years and teenage girls were particularly frequent victims A total of 138 patients were injured while riding whereas 65 were injured by the horse before or after riding

The accidents resulted in 231 injuries of which 72 per cent included soft tissue injury while 28 per cent were fractures The majority of fractures were in the upper extremity Eighty seven per cent of the patients were treated as outpatients and 13 per cent were admitted to the hospital In contrast to some earlier reports it is concluded that the majority of injuries following horse riding accidents are rather insignificant Adequate headgear would lessen the severity of several head injuries It is believed that it is possible to reduce the number of accidents by better instruction of beginners

MEASUREMENTS OF THE UPTAKE OF STRONTIUM 85 FOR THE DIAGNOSIS OF STRESS FRACTURES IN THE TIBIA

Nils Westlin & Bo Wendeberg
Malmo Sweden

Thirty five athletes with pain in the medial aspect of the lower leg were investigated for possible stress fractures by measuring the uptake of Strontium 85 Eight of these patients had a normal uptake in the tibia and did not show any radiological signs of stress fracture seven had distinctly localised increased uptake which corresponded to the radiological finding of a stress fracture In the remaining 20 patients the uptake of Strontium 85 was increased along the entire tibial diaphysis None of the latter group had any radiological signs of fracture

The first group probably consists of patients with pain unrelated to bony structures The second was classified as cases with stress fractures two cases in this group had no radiological signs of fracture at the time of the uptake measurement but the diagnosis became evident later on

The findings in the third group may be interpreted in several ways Either these are cases with tibial stress fractures already radiologically healed which is conceivable since these cases were usually measured later in the course Another possibility is that we have here a separate clinical entity in which the increased uptake is caused by a periosteal reaction—tibial periostitis

FASCIOTOMY FOR TREATMENT OF LOWER LIMB PAIN IN ATHLETES

Nils Westlin & Bo Wendeberg
Malmo Sweden

Pain in the lower leg is a common symptom in athletes particularly in runners Those athletes who have the symptom seem to have in common that they employ muscles in the tibialis posterior compartment and particularly toe flexor muscles extensively Upon the assumption that hypertrophy of the muscles by an increased pressure in the closed compartment may cause distension of the fascia attachment to the tibia with ensuing pain we have operated upon 31 cases with recurring or chronic symptoms by dividing longitudinally the fascia of the posterior compartment At follow up 25 ± 15 months after operation 23 cases out of the 31 studied were completely free of symptoms five were improved and three unchanged Twenty one

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TREATMENT OF MUSCLE RUPTURES

Sten Otto Liljedahl
Linköping, Sweden

Partial and total ruptures of muscles usually occur in runners and members of various team sports. Muscle ruptures are divided into two groups: ruptures by distension and ruptures by compression. Compression ruptures are most common in the deep layers of the thigh muscles and the lower leg. The diagnosis is made by clinical examination, X-ray and electromyography. Compression ruptures can be confused with soft tissue tumours. The differential diagnosis is made by fine needle biopsy. In one of the cases a false aneurysm and in another a liposarcoma simulated a compression rupture. Both cases were correctly diagnosed and treated.

Small ruptures are treated conservatively. Layer ruptures with a large haematoma should be operated on. The haematoma is evacuated and the ruptured muscle tissue sutured. Distension ruptures may safely be operated on after several months. In some of these cases no spontaneous healing of the rupture has been observed in spite of the operation having been performed after 6 months.

DYNAMIC ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION OF THE KNEE JOINT

K. Solonen & M. Vastamäki
Helsinki, Finland

A dynamic anterior cruciate ligament was constructed in 40 patients with a traumatic lesion of the ligament. In 15 cases it was a sports injury. The patients had 75 ligament lesions in all. The most common combination, found in 21 cases, was rupture of the anterior cruciate and tibial collateral ligaments.

Twenty five patients had been operated on previously 31 times because of the same knee injury. Twenty four patients had a lesion of a semilunar cartilage.

The tendon of the gracilis muscle was cut off at the insertion and led through the joint along the normal course of the anterior cruciate ligament and through a bony tunnel from the eminentia intercondylica tibiae to the front surface of the bone where it was fixed. The postoperative immobilization time was 6 weeks.

The results were estimated on an average 2 years after the operation. The result was excellent or good in 23 cases, fair in 12 cases and in 5 cases the function of the joint was [illegible] a dynamic [illegible]ually wall [illegible] method is a good alternative to be considered when planning treatment of patients with anterior cruciate ligament lesion of the knee joint.

END RESULTS OF SURGICAL TREATMENT OF FRESH INJURIES TO THE MEDIAL COLLATERAL LIGAMENTS OF THE KNEE

O. J. Fasting
Sønderborg, Denmark

The results of primary suture within 2 weeks after trauma were analysed on the basis of a follow up of 24 patients, 2 to 10 years after treatment. Sixteen patients were more than 40 years old. Only five had sustained their injuries during sport. Sixteen had injured the medial meniscus and undergone meniscectomy. The distribution into different groups according to subjective complaints, "good", "fair" or "poor" was based on written answers to definite questions in a questionnaire. All patients underwent a physical and roentgenological examination.

Eight patients had no complaints at all and the others complained to varying degrees. The result was "good" in 12, "fair" in 8 and "poor" in 4. Slight instability was found in 8 cases but seemed to have had no influence on the result. Only one had instability due to non union of the ligament and the result was "poor". Crepitation in the joint was found in eight cases and four cases had slight radiological osteoarthritis. Twelve cases had para articular ossifications, four with local tenderness but the influence on the complaints was slight.

The results indicate that rupture of the medial collateral ligament of the knee should be treated with suture and a stable ligament can be obtained without grafting. The unsatisfactory results were mostly due to factors other than stability of the ligament.

HEMARTHROSIS IN KNEE INJURY

Per-Erik Wiklund
Malmö, Sweden

Out of 276 consecutive knee injuries hemarthrosis was found in 106. In those cases who did not have hemarthrosis there was only one serious knee injury whereas more than half of the cases with hemarthrosis had fracture or total ligamental rupture. Of the hemarthrosis cases half of those with direct trauma had fracture. Those with a knee distorsion injury sustained a fracture in only a few cases whereas partial or total ligamental ruptures were common. Cases with hemarthrosis and trauma that could not be clearly defined had fractures as well as total ligamental ruptures. Also all the patellar dislocations were found in this group. It is proposed that with knowledge of the type of trauma after puncture of the joint in suspected cases and roentgen examination of those with hemarthrosis a group of patients can be distinguished who have hemarthrosis

after a joint distorsion or after a less well defined trauma who need further investigation such as stability tests under anesthesia in order to exclude total ligamental ruptures

KNEE INJURY RATE IN FOOTBALL PLAYERS AND IN THE POPULATION AT LARGE

A Roaas & G B J Andersson
Goteborg Sweden

One hundred male football players (soccer) chosen at random among retired and active players in divisions 1–4 were studied together with 108 males in the same age group (30–40 years) chosen to represent the male population of Goteborg Sweden Physical activity previous injuries and diseases were explored. A clinical investigation including objective studies of lateral stability and X ray studies of the knee joints was carried out

Sixty five per cent of the football players had sustained an injury complained of present dif ficulties or had pathological findings at the time of investigation In the population as a whole the corresponding figure was 34 per cent and when football players in this group were excluded 24 per cent Injuries to the menisci and medial collateral ligaments were the most frequent Twenty nine per cent of the football players had sustained lesions of the menisci and 16 per cent lesions of the ligaments In the population the percentages were six and four respectively and when football players were excluded four and two

Complaints were few in this age group Clinical instabil ty was present in 8 per cent of all those investigated in 38 per cent of subjects with previous injuries and in 44 per cent of subjects operated on for meniscus lesions Osteo-arthrosis with reduced jo nt space medially was found in four knees

MENISCECTOMY A 10 YEAR FOLLOW UP OF 150 ATHLETES

S Sonne Holm N C Ahn & I Fledelius
Gentofte, Denmark

The object was to elucidate the consequences for an athlete of injury to and removal of the meniscus and the social cost of meniscal in juries sustained during sports activities

The study included 154 meniscectomized pa tients who had sustained their injury while playing sports Three per cent were lost to follow up The median age at operation was 24 years More than half the injuries had oc curred during football games The median fol low up period was 4 years (range 2 11) Patients with a short follow up period (≦ 47 months) had received a more intensive physical training than had those with a long follow up period (altered regime in the Unit) However this entailed no change in the number of lost work ing days (median 30 days)

Seven per cent had a poor subjective result Twenty eight per cent had given up sport or had been obliged to restrict their athletic activ ities because of the meniscectomy The most common complaints were pain on weight bear ing a sensation of instability, and intermittent effusion into the knee Among patients with a short follow up period 19 per cent had radio logical osteoarthrosis as compared with 27 per cent among those with a long follow up period (NS) There was no correlation with the subjec tive complaints Fairbank s changes (flattening of the femoral condyle formation of marginal osteophytes on the tibial condyle) correlated positively with the subjective complaints and with osteoarthrosis

Hospital expenses and production loss per patient were calculated to amount to about 13 600 kroner (1975 prices)

INJURIES IN NORWEGIAN FOOTBALL PLAYERS A FIVE YEAR INSURANCE MATERIAL

Asbjorn Roaas & Svein Nilsson
Oslo Norway

All Norwegian football players are covered by insurance through the Norwegian Football As sociation No team is allowed to play obligatory matches until the insurance premium has been paid

Football injuries are registered by the football association 3616 injuries from the period 1970–1974 have been analyzed First division clubs seem to have a higher injury rate per club than clubs in other divisions but they also have more players and spend more time playing football Adult players have an injury rate five times higher than adolescents Fifty two per cent of the total number of injuries are located in the lower extremities Fractures represent 42 per cent of the injuries Fractures of the leg amount to 13 per cent of the injuries 25 per cent of the compensation money and 30 per cent of the number of days lost from work. The insurance company paid 1 5 million Nkr to the injured players during the period.

91 500 days lost from work were registered but this is a minimum figure since usually only injuries resulting in more than 14 days sick leave were registered

RUPTURE OF THE LATERAL LIGAMENTS OF THE ANKLE JOINT IN ATHLETES. OPERATIVE VERSUS NON-OPERATIVE TREATMENT

H Emnéus, O Gunnerup & H Gregersen
Aalborg, Denmark

Two series of patients with ankle sprains were compiled from two accident services in Aalborg In one, arthrography was used and the torn ligaments were sutured, in the other the sprains were non operatively treated

In the surgical material 40 per cent were athletes and soldiers, the mean age was lower, and men dominated In the conservative series 20 per cent were athletes, the mean age was higher and there was no sex difference

At the review it appeared that 39 out of 41 sutured cases had regained full athletic activity, 32 with unlimited athletic activity had no complaints, while 7 had slight discomfort but full activity Of the 23 non sutured cases, 20 had regained full athletic activities, but 9 had slight discomfort

CLINICAL, ROENTGENOLOGICAL AND SOCIAL CONSEQUENCES OF RUPTURE OF THE LATERAL LIGAMENT OF THE ANKLE

H Hansen V Damholt & N B Termansen
Odense, Denmark

149 patients (95 men and 54 women) with rupture of the lateral ligament of the ankle were followed up with an observation time from 3 to 6 years, the average being 4 2 years The average age of the material was 26 7 years The diagnosis was based on an inversion stress radiograph showing a difference of more than 6° in talar tilt between the injured and uninjured side The treatment was plaster of Paris (4–6 weeks) in 130 cases, elastic bandage in 14 and operation in five cases

Work and sport were responsible for 62 per cent of the ruptures 20 per cent had residual symptoms at follow up mainly functional instability, but only 2 7 per cent had severe symptoms Plaster of Paris and elastic bandage treatment gave equal results

We found no connection between the degree of talar tilt immediately after the ligament rupture and the residual symptoms There was no connection between the talar tilt at follow-up and residual symptoms Ninety two of the patients were sportsmen, 46 football players Twenty per cent of the football players had to give up football Other sports were not affected The ability to work was not affected

ISOMETRIC STRENGTH MEASUREMENTS OF THE CALF MUSCLE IN 30 YOUNG, NORMAL SOLDIERS AND IN 146 PATIENTS TREATED CONSERVATIVELY FOR RUPTURE OF THE LATERAL LIGAMENT OF THE ANKLE

V. Damholt, N B Termansen & H Hansen
Odense, Denmark

In 30 normal, young soldiers there was no statistically significant difference in strength between dominant and non dominant legs but a significant difference in strength was found in favour of the right leg in relation to the left leg The difference was slight, less than 5 per cent, and without any clinical consequence There was no correlation whatever between isometric strength and circumference of the calf

In 146 patients, treated conservatively for rupture of the lateral ligaments of the ankle there was reduced strength in the affected legs The difference was slight, about 5 per cent but statistically significant In 27 cases with residual symptoms after 4 years of observation there was a greater difference between the affected and unaffected legs, about 7 per cent Also the unaffected legs had a reduced strength indicating asthenia in the legs of patients with residual symptoms after rupture of the ligaments of the ankle There was no correlation between strength and circumference of the calf muscle

THE EFFECT OF OESTRADIOL ON BONE METABOLISM

Norvald Langeland
Oslo, Norway

Castrated female rats were treated with different doses of oestradiol, and the collagen metabolism in bone was studied *in vivo* and *in vitro* The results were compared to the findings in normal uncastrated and castrated untreated animals

Castrated animals had the highest collagen resorption rate and the highest collagen synthesis rate Most of the treated groups did not differ significantly from normal controls in any respect Oestradiol had no effect on collagen metabolism in bone of hypophysectomized rats In castrated thyroparathyroidectomized animals oestradiol had approximately the same effect as in castrated controls PTH added *in vitro* produced an elevated collagen resorption rate while oestradiol added *in vitro* had no influence on this effect

EFFECT OF INDOMETHACIN ON FRACTURE HEALING IN RATS

J Rø E Sudmann & P F Marton
Oslo, Norway

The healing of closed standardized mid diaphyseal left femoral fractures was studied in 129 male adolescent albino rats divided into two weight matched groups given indomethacin 2 mg/kg/day and placebo, respectively The first dose was given immediately after each fracture was made Immediate weight bearing was allowed without fixation Isolated femur callus specimens were subjected to radiological examination and mechanical strength testing on days 6 9 12, 18 and 24 after fracture Eight fractures were studied histologically on days 9, 12, 18 and 24

In the control animals the fractures healed within 18 to 24 days In contrast, indomethacin 2 mg/kg/day given orally seriously impaired fracture healing

ELECTRICAL STIMULATION OF OSTEOGENESIS IN TWO CASES OF CONGENITAL PSEUDARTHROSIS OF THE TIBIA

A Nachemson, G von Salzger & E Herbst
Goteborg Sweden

The two 4 year old patients with congenital pseudarthrosis of the tibia had both been operated on twice previously without lasting healing when in 1973, as an alternative to amputation we started treatment with electrical stimulation We used—with some modifications the method developed by Jorgensen (1972)

After closed correction of the angular deformity, an external fixation frame was applied to which the stimulator was attached The bone screws served as electrodes, the one next to the pseudarthrosis as the cathode The stimulator delivered monophasic current pulses with pulse amplitude of 30 μA, pulse duration 0 5 s and frequency 1 Hz

The boy M A, was treated with electrical stimulation for two periods of time The pseudarthrosis was considered healed after the first period of 4 5 months Two months later he got a spontaneous fracture in spite of wearing a long leg brace This fracture healed radiographically in 6 weeks and clinically after 3 months of treatment The girl J P was treated with electrical [illegible]

[illegible] and 3 weeks and for the girl 7 weeks

The advantages of this method are 1) the effective and light external fixation as compared to a plaster cast, 2) the possibility of stimulating 24 hours a day, 3) the possibility of free movement during stimulation time without confining the patient to bed or to any apparatus and 4) the minimal discomfort for the patient.

Jörgensen, T E (1972) Acta orthop scand 43, 421–437

EXPERIMENTAL TRANSPLANTATION OF OSTEOCHONDRAL ARTICULAR FRAGMENT A PRELIMINARY REPORT

K Østerman & S Lindholm
Helsinki, Finland

In the treatment of osteochondritis dissecans of the knee the loosened osteochondral fragment can be fixed to its bed using thin autogenous cortical bone pins To test the experimental basis for this operation, a study, using rabbits as experimental animals, was planned An osteochondral defect in the articular surface of the medial femoral condyle was created with a low speed drill The defect was reconstructed by using a local fresh autogenous osteochondral fragment, homogenous transplant or a fragment which was left free in the joint and fixed later A stable fixation was achieved by using autologous cortical bone pins The results were evaluated by using clinical testing, histology, tetracycline labelling and microradiographs The preliminary results show that good stability can be achieved by using the bone pin fixation The tip of the bone pin gradually disappears from the articular surface and is replaced by fibrous cartilaginous tissue The remodelling in the osteochondral fragment occurs over a long period Good anatomical reconstruction of the articular surface ensures the best operative results The experimental observations correlate with the clinical experiences

OSTEOCHONDRITIS DISSECANS DRILLING AND BONE PEGGING

Sam Lindholm, Pauli Pylkkänen & Kalevi Østerman
Helsinki, Finland

In addition to internal fixation using stainless steel nails we have gained some experience of bone pegging of osteochondritic fragments in the knee (Lindholm & Pylkkanen 1974)

Sixteen patients with a mean age of 20 years, suffering from an osteochondritis dissecans lesion in the femoral condyle, were operated on In all cases the fragment was totally or partially connected to the weight bearing surface of the joint and appeared at site (12 cases), connected with a stylus (3 cases) or as a loose body (1 case)

Measures were modified with respect to the pathological situation of the fragment. In some

cases spongeous bone was transplanted to the bed of the fragment. Holes were drilled through the fragment, and cortical pins obtained from the upper tibia were used for fixation in some of them.

All patients were followed up for an average of 4 years after grafting, 16 years being the longest period. All fragments united after an average of 4 months. A resorption process was recognized in the distal ends of the pins. Slight osteoarthritic changes were observed in one patient. Nine patients were symptom free, whereas the others sometimes noted slight tenderness in the joint. They all walked normally, one had a slight recurrent hydrops, and six a quadriceps atrophy of about 1–2 cm. A small deterioration of movement was recorded in three knees. According to the subjective symptoms and the clinical re-examination, including X-rays, the follow-up results were classified as excellent in 5, good in 8 and fair in 3 cases. No poor results were noted.

Lindholm, S. & Pylkkänen, P. (1974) *Acta chir. scand.* 140.

POROUS CERAMICS AS A BONE SUBSTITUTE IN THE MEDIAL CONDYLE OF THE TIBIA

P. Benum, S. Lyng, N. Johannessen & T. Alm
Oslo, Norway

A new porous ceramic material consisting of Al_2O_3 (99 per cent) and CaO, MgO and SiO (1 per cent) was tested for possible use as a bone substitute in regions mainly exposed to compressive forces. The pore size varied from 100 μ to 1000 μ, the compressive strength of the material was, on average, 27 MN/m^2.

The porous ceramics were implanted into the medial condyle of the tibia in adult sheep and left in position for 3, 10 and 12 months. The operated tibia was removed at sacrifice, and the results were evaluated by radiography, microradiography and transmitted light microscopy. The short term implants were also studied by scanning electron microscopy.

At 3 months the implants were found to be bound to the adjacent bone by ingrowth of bony tissue, in some regions to a depth of 2.3 mm. In the long term observations no signs of loosening or collapse of the implants were seen. The maximal depth of bone invasion was slightly increased being 3–4 mm. Some ossification was still taking place. The ceramics were well tolerated, however, some foreign body cells were seen.

Based on these experimental results a clinical trial has been started with porous ceramics as a bone substitute in compression fractures of the tibial condyles. Fibre reinforced ceramics are under development in order to produce a ceramic material more suitable for prosthetic devices.

FRACTURE REPAIR AFTER RIGID PLATE FIXATION WITH AND WITHOUT COMPRESSION

T. Holmström, P. Slätis, E. Karaharju & P. Waris
Helsinki, Finland

Experimental transverse osteotomy through both mid tibial shafts was stabilized in 52 rabbits with a six-hole dynamic compression plate (ASIF). On the right tibia axial compression was applied to the plate, whereas the left tibia of the same animal was plated without concomitant compression. In addition both mid tibial shafts were plated in a similar way in 50 rabbits without transverse osteotomy of the bone. Specimens of bone under the plate were investigated radiologically, histologically and by fluorescence microscopy.

Fracture union was achieved uniformly within 12 weeks, regardless of the use of compression. Primary healing of the osteotomy gap could be observed, characterized by a negligible amount of periosteal callus, enlargement of the Haversian canals, appearance of cutter heads in the bone and formation of new bone in the resorption canals traversing the bone transection. Porotic transformation was a common feature both in osteotomized and intact bone causing cancellous transformation of the cortex, subendosteal resorption and thinning of the cortex. The magnitude of porotic changes were the same in bones plated with compression and without compression.

The results indicate that rigid plate fixation induces porotic changes in the cortical bone and that axial compression applied to the plate does not have any additional beneficial or untoward effect on the rate and mode of fracture repair.

BIOMECHANICAL EVALUATION OF FRACTURE HEALING AFTER RIGID PLATE FIXATION

P. Paavolainen, P. Slätis, T. Holmström, K. Aalto & J. Ahonen
Helsinki, Finland

The repair of experimental transverse osteotomies through the midshaft of the tibio-fibular bone was analysed in rabbits by microradiography, histology and measurement of the torque capacity of the bone. In 52 animals the right and the left tibio-fibular bone was osteotomized and stabilized with a 6-hole dynamic compression plate (ASIF). On the right side compression osteosynthesis was made whereas on the left side the plate was attached to the bone without axial compression. The animals were sacrificed from 1 to 24 weeks after the operation and the tibio-fibular bones tested to breaking point in a torsion machine. Samples

of bone from the osteotomy site and adjacent areas were additionally microradiographed and studied histologically

The torque capacity of the bone increased gradually from the third week after the operation The osteotomy united on both sides within 6 weeks after which the torque capacity equalled that of the adjacent bone Increasing porotic changes were observed however in the bone under the plate Due to these structural changes the torque capacity data obtained remained subnormal throughout the experiment

The results indicate that rigid plate fixation of a transected tubular bone provides conditions for swift primary healing of the fracture gap, that axial compression added to the metallic implant has no significant beneficial effect on the mode of repair or on the torque capacity of the injured bone and that rigid plates induce structural changes in the cortical bone which adversely affect the torque capacity of the operated bone after union between the fragments has been achieved

EXPERIMENTAL OSTEOARTHRITIS IN THE RABBIT KNEE JOINT

H Bohr
Kalundborg Denmark

The arthrotic like changes in the rabbit knee joint following resection of the crucial ligament were studied Thirty five animals were operated upon including five where only the medial meniscus was removed as a control Histological investigations including microradiography were performed on undecalcified and decalcified specimens In all animals scintigraphic recordings with radioactive fluorine and technicium polyphosphate were made once or several times and in some cases microangiographic investigations with perfusion of micropaque were performed The earliest changes consisted of deficient metachromatic staining of the cartilage This was followed by fibrillation and formation of cell clusters About 1½ months after the operation changes in the subchondral bone appeared with hyperaemia and formation of osteophytes through penetration of vessels into the cartilage Scintigraphic results indicated that hyperaemia reaches a maximal value about 3 months after the operation and then diminishes despite further development of the arthrotic changes In the control animals only slight arthrotic changes appeared and the uptake of radioactive indicators was less pronounced

FRACTURES OF THE FEMUR IN YOUNG CHILDREN

Ulf Slungaard
Oslo Norway

The degree of anteversion in the femoral neck was radiographically measured in eight adults who at the ages of 1½ to 3½ years had sustained dislocated fractures of the shaft of the femur All had been treated with adhesive plaster traction applied vertically to the injured leg One patient suffering from osteogenesis imperfecta had been treated three times in this way for repeated fractures of the same femur At the follow up investigation radiographic measurement of the anteversion of the femoral neck revealed that the difference between the unaffected and the previously injured femur did not in any case exceed 9° The results indicate that adhesive plaster traction applied only to the affected leg is sufficient treatment for fractures of the femur in children under 3 years of age

EPIPHYSEAL GROWTH AS A CORRECTING FACTOR OF DEFORMITY

S Ryöppy E Karaharju & R Makinen
Helsinki Finland

Spontaneous correction of post traumatic deformity of a growing long bone is a clinical fact but the mechanism of this process and the factors influencing it are not known in detail The authors have so far been able to demonstrate that correction of position subsequent to experimentally produced deformity takes place to a considerable extent through epiphyseal growth By changing the experimental method so that a fixed point in the diaphysis permitted exact measurement of the direction of the axis the role of epiphyseal correction could be calculated separately

A valgus osteotomy was created in the legs of 20 young dogs and fixed with bent plates From radiographs taken at intervals of 2 weeks the epiphyseal and axial angles were measured It was found that the axial angles corrected rapidly during the first 60 days and more slowly towards the end of the period of study 160 days The epiphyseal angle which was zero in the beginning increased gradually and the average correction during the 160-day period was 12 5 ± 0 3°

Some animals were given tetracycline 10 to 20 days before death Results of calculations made from these specimens agreed exactly with the radiological measurements When these results were compared with the total correction of the deformity it could be concluded that the epiphyseal correction accounted for roughly half of the total correction Some other factors are

certainly involved in the process, but their role in the correction is so far unclear

PSEUDARTHROSIS OF THE SCAPHOID BONE

Lasse Kvarnes
Oslo, Norway

The late results of treatment in 58 patients with pseudarthrosis of the scaphoid bone were analysed Eleven patients were immobilised using plaster of paris eight patients had a *radiocarpal arthrodesis and 39 patients were* treated by transplantation of autogenous bone or by compression osteosynthesis

Re examination approximately 5½ years later revealed a good clinical and radiological result in 88 per cent of the patients treated by com pression osteosynthesis or autogenous bone grafts Among the conservatively treated patients the result was successful in 62 per cent

A third of the patients still had a pseud arthrosis but many of these reported a reduc tion in subjective complaints

HIP SCANNING IN PATIENTS WITH INTRACAPSULAR FRACTURE OF THE FEMORAL NECK

D Zdravlovic A B Christensen S P Nielsen & J O Hartling
Gentofte, Denmark

The series included 22 patients (17 women and 5 men) with an average age of 73 5 years The fractures were divided into 12 subcapital and 10 transcervical fractures There was no difference in femoral head activity between the subcapital and the transcervical fractures How ever there was an increased activity in the caput femoris in cases with poor fracture align ment and this difference increased at the *3 month scanogram*

FRACTURE OF THE FEMORAL NECK—A SOCIO MEDICAL PROBLEM

O Ødegård & G Unsgård
Trondheim Norway

Out of 878 patients treated for femoral neck fracture during the period 1970 to 1974 775 cases have been analyzed with regard to their social background as related to length of stay in hospital functional result of treatment and re habilitation

The youngest patient was 8 years old the oldest one 100 years the mean age was 71 The majority of cases belonged to the age group 70–79 years Seventy seven per cent of the pa tients were brough in from their homes only very few came from old people s homes and the rest from nursing homes and geriatric wards

The usual treatment is plate nailing bu femoral head prostheses have been used increas ingly in the treatment of displaced med a femoral neck fractures in patients more than 70 years old

On the whole men were outnumbered 3 1 by women as regards incidence However in the younger age group the proportion of men was relatively larger, while over 70 years the propor tion of women increased rapidly Married men had a shorter hospital stay than married women but no other difference in length of hospitaliza tion related to marital status could be en countered

Seventy nine per cent of patients below 50 could walk without any aid 6 months after injury but only 26 per cent of patients over 90 could do this

LOCAL CHEMICAL TRAUMATIZATION OF BONE CEMENT

Lars Linder
Goteborg, Sweden

It is known that methyl methacrylate mon omer leaks from polymerizing bone cement As the monomer is cytotoxic a local tissue injury can be expected

By intravital microscopy in the hamsters cheek pouch it was shown that monomer leak age caused severe, localized and irreversible microvascular changes

Small cylinders of cement were then inserted through 3 6 mm drill holes on the proximal medial side of the rabbit tibia One tibia re ceived cement in the doughy state and the other received already polymerized cement The cement volumes were so small that no significant tem perature rise took place

Observation times were 10 20 30 and 70 days and methods of analysis were histology micro angiography microradiography and fluorochrome labelling

No difference in the tissue response to the test and control implants was seen A 100–300 micron necrosis was seen round both implant types and during the course of the experiment new bone formation took place It is concluded that in this experimental model the monomer leakage causes less tissue injury than the al ready minimized surgical trauma

^{99m}Tc PYROPHOSPHATE SCINTIGRAPHY IN LOOSENING OF TOTAL HIP JOINT REPLACEMENT

O J Fasting I Gabor I Hertzenberg & K F Nallen
Oslo Norway

Scintigraphy was performed on 30 hips more than 1 year after Weber total hip joint replace-

ment. 10 mCi ^{99m}Tc pyrophosphate was administered i.v. 4 hours before scintigraphy, using a gamma camera connected to a computer unit The radioactivity was calculated both as a count index, comparing hip activity with normal bone activity in the lumbar spine, and subjectively from the gamma camera picture

An increased activity around a component of the replacement correlated well with the clinical and radiological signs of loosening and with the operative findings in 20 cases reoperated upon However, there were also cases with false negative as well as false positive findings at the scintigraphy

Phosphate complexes labelled with ^{99m}Tc have many advantages compared with the formerly used agents such as ^{85}Sr ^{87}Sr and ^{18}F, and though there are differences in biochemical behaviour between these agents they seem to give similar clinical information The method can be useful in differential diagnosis of complaints after total hip joint replacement The interpretation of the scintigraphy is difficult and the degree of uptake of the tracer is not conclusive but it can be used as another objective sign and as a complement to clinical and radiological findings

MECHANICAL LOOSENING OF THE CHARNLEY STEM PROSTHESIS

Ake S Carlsson & Carl Fredrik Gentz
Malmö Sweden

Between 1968 1972 altogether 351 Charnley hip replacements were performed Of these 69 hips had infection or loosening of the acetabular prosthesis Out of the remaining 282 hips, observed for at least 1 year 83 (29 per cent) showed radiological signs of mechanical loosening A radiolucent zone 1–12 mm wide, along the lateral edge of the stem appeared between 1 70 months postoperatively Insufficient cement fixation at the calcar level as well as under the distal end of the prosthesis was significantly more frequent in cases with loosening Loosening was significantly more frequent in men than in women and in younger and heavier as compared with older and leaner patients Only half of the patients with loose stems had weight bearing pain and it is suggested that the radiological signs of loosening precede the clinical symptoms and that the proportion of patients with symptoms may increase with time A sufficient amount of cement at the level of the femoral calcar and below the end of the prosthesis is of importance in preventing loosening Also a varus position should be avoided

FRACTURE OF THE CHARNLEY STEM PROSTHESIS

Ake S Carlsson, Carl Fredrik Gentz & Jan Stenport
Malmo and Stockholm, Sweden

Since the Charnley total hip prosthesis was introduced in Sweden in 1967, 10 fractures of the stem prosthesis have been recorded The fractures were noticed 14–62 (40 ± 15) months after surgery and were always preceded by radiographic signs of loosening Nine occurred in males and one in a female patient These patients were heavier than average but did not deviate in age In only one patient was the contra lateral hip normal Five of the fractures were overlooked initially but were found when the radiograms were reviewed Eight of the fractured stems were in a varus position two in a neutral position and only one in valgus It is concluded that heavy male patients with the prosthesis in varus and with a poor proximal and a rigid distal cement fixation are predisposed to this complication

RESULTS OF REVISION OPERATIONS OF LOOSENED AND INFECTED TOTAL HIP PROSTHESES

T Visuri & L F Laurent
Helsinki, Finland

In 1967–1973, 545 McKee Farrar total hip replacements were performed A revision operation was necessary in 38 cases Four hips operated on originally in other hospitals were included in the series Reapplication was done in 34 patients and excision of the prosthesis in eight infected cases The reason for reoperation was loosening in 38 recurrent dislocation in two, perforation of the femoral cortex by the stem and malpositioning of the stem with a fracture of the proximal femur, each in one case Previous operations were important causative factors as regards loosening A deep infection was the cause of loosening in 12, trauma in nine, malpositioning of the prosthesis in six, other factors (cobalt allergy spontaneous fractures, non matching parts of the prosthesis) in five, and unknown factors in six hips The acetabular part loosened in 30 patients, between the bone and the cement in every case The femoral part loosened with the cement in five and without the cement in 15 patients If the prosthesis loosened at the time the patient began to have pain on weight bearing, this took place immediately after the operation in seven and during the following year in 11 cases In the course of time loosening occurred less frequently

The results were evaluated according to the system of Merle d Aubigné & Postel Twenty-one hips were classified as good or fair and 13 as

poor Relatively good results were achieved when the cause of loosening was trauma or malpositioning of the prosthesis (12 good or fair, 6 poor results) Poor results were achieved with infected or dislocated hips Our experience of the use of a cement mixed with gentamycin and massive antibiotic treatment in the reapplication is limited so far Without these precautions a simple excision is indicated in infected hips

CONGENITAL DISLOCATION OF THE HIP

Nis Fredensborg
Malmo Sweden

In the city of Malmo, 58 759 newborn children were examined for congenital dislocation of the hip during the years 1956–1972 In 548 children the diagnosis was made within 48 hours In four children the condition was not noticed initially This is extremely few but in accordance with the findings of other investigators

In order to investigate the late results of treatment, 111 children treated with the von Rosen splint during the years 1956–1964 were re examined Clinically all were normal Radiologically the general appearance was found to deviate in two children In one hip the femoral head and neck were slightly enlarged as the result of early avascular necrosis and in one hip the acetabular roof was somewhat steep Otherwise, acetabular development (measured as the CE angle) and the roundness of the femoral head (measured as the spherical index) were identical in treated children and in a control group of normal children with the same age and sex distribution

Thus all or almost all children with congenital dislocation of the hip can be diagnosed at birth If correctly treated a completely normal development of the hip can be expected

THE LOAD ON THE HIP JOINT—PAUWELS THEORY

H Glastrup
Stege, Denmark

The pressure on the caput under normal conditions in the normal hip joint, and in hip joints affected by coxa valga and coxa vara has been reviewed

The following symptoms are characteristic of dysplasia of the hip Low back pain radiating to the hips, and pain in the adductor muscles and pedes anserinae

Physical examination demonstrates hypermobility in the hips tenderness on palpation posteriorily laterally and anteriorily over the hip joint and tenderness of the adductor muscle and pedes anserinae

Pauwels' technique endeavours to obtain better conditions of load in the hip joint thus preventing pain and osteoarthritis

COXA VALGA TREATED BY VARISATION OSTEOTOMY *AD MODUM* PAUWELS

H Glastrup
Stege, Denmark

Pauwels' technique has been modified to avoid hip plaster A wedge of approximately 20° is excised between trochanter major and minor the base medial anterior, the apex lateral posterior The osteotomy is fixed with a children's nail and Hubbard s plate by means of 3–4 screws

67 hips have been operated upon in 54 patients 21–63 years of age One died 6 weeks after the operation due to pulmonary emboli and two later of unrelated disease

The subjective condition at follow up was excellent and good 40 fair 6 poor 5 The clinical condition at follow up was excellent and good 40, fair 8, poor 3 Radiographic examination of the 67 hips demonstrated excellent and good 57, fair 5 poor 5

The longest observation period was 13 years Long term observation ought to be 20–40 years

DISLOCATION OF THE HIP IN MYELOMENINGOCELE

Cato Hellum
Oslo, Norway

The main reason for hip dislocation in myelomeningocele is muscular imbalance This is especially liable to occur at level L_3–L_4 At this level there are active hip flexors and adductors, and paralysed extensors and abductors Treatment aims at restoring muscular balance This can be done by transferring m iliopsoas to trochanter major *ad modum* Sharrard Forty three hips (29 patients) have been operated on in this way over the last 10 years

The results were as follows the caput in a good position in 16 hips improvement but dysplasia/subluxation in 11 hips failure (luxated as before) in 13 hips and in three hips the observation time was less than 6 months

The results are mediocre if considered from a purely dislocation of the hip point of view However, in this severely handicapped group of patients the following points should be emphasized All patients have major paresis and gluteal insufficiency All use splints and crutches None has pain Most important are the contractures found both in dislocated as well as in nondislocated hips Thus, hip dislocation is of relatively little importance Moreover, these pa

tients have paralysed legs, pressure sores, urinary incontinence, threatening hydrocephalus and social problems They constantly require follow up or treatment

Iliopsoas transfer should be done at an early stage, preferably within 1 year Later, nothing more than the correction of contractures is advocated.

BONE SCINTIGRAPHY IN CALVÉ LEGG PERTHES' DISEASE

O J Fasting, N. Langeland, I Bjerkreim, L Hertzenberg & K. F. Nakken
Oslo, Norway

^{99m}Tc pyrophosphate was used to study circulation and metabolic activity in the femoral

minor changes, the scintigraphic picture disclosed reduced activity in parts of the femoral head Later in the course of the disease, areas were found with increased activity, and in the final stage a normal distribution of radioactivity was observed

The method seems helpful in the diagnosis and in the study of the course of CLP

FEMORAL OSTEOTOMY IN COXA PLANA

S Friberg, B Lundius, T Persson, B Tillberg & J Aström
Umeå, Sweden

The radiographic results after femoral derotation and varisation osteotomy in coxa plana were evaluated in 47 hips These results were compared with those obtained after conservative treatment (Thomas' splint) in 45 hips The material was grouped according to the primary degree of necrosis of the epiphysis (Catterall 1972)

The evaluation of the epiphyseal and joint surface quotients showed that no *differences* in [illegible]

[illegible] *these two parameters* and the primary degree of necrosis

The influence *of type of treatment*, age, sex, side and primary degree of necrosis on the results derived *from a general* assessment of the radiographs (Table 1), was evaluated by step wise regression *analysis This* analysis showed that the degree of primary necrosis was *highly* correlated to the results ($P < 0.001$) A weak correlation was found *to age* ($0.05 < P < 0.01$) No correlation existed *between the results* and type of treatment, sex or side

Table 1. Results derived from a general assessment of the radiographs

	Osteotomy			
	Degree of necrosis			
	1	2	3	4
Good	100%	35%		
Fair		61%	50%	43%
Poor		4%	50%	57%
No of cases	2	26	12	7

	Thomas' splint			
	Degree of necrosis			
	1	2	3	4
Good	100%	44%		
Fair		56%	67%	33%
Poor			33%	67%
No of cases	8	16	12	9

ARTERIAL INJURIES CAUSED BY BLUNT TRAUMA OF THE EXTREMITIES ASPECTS OF DIAGNOSIS AND TREATMENT

Tor Bierlon & Ake Hjelmstedt
Uppsala, Sweden

The purpose of this report based on 25 "orthopaedic vascular cases" is to emphazise the importance of early recognition of ischaemia in cases of blunt non penetrating trauma to the *extremities Arterial* spasm without damage to the arterial wall is extremely rare The attitude of wait and hope for spontaneous improvement is dangerous Treatment with sympathetic block *is* a waste of time Preoperative arteriography *is useful if* performed without delaying the arterial repair In traumatic arterial occlusions due to blunt trauma (compression, dislocation, fracture) rupture of the intima *followed by an* occluding thrombus is a frequent mechanism The aim is to restore a pulsative arterial flow in the injured artery within 6–8 hours Resection of the *injured* arterial segment and reconstruction with autogenous reversed vein graft end to end *is the method* of choice If too small a resection is performed followed by direct arterial suture under tension reocclusion is apt to appear Loss of distal pulses in the postoperative *period demands* immediate re exploration If massive swelling is present preoperatively *or develops* during or after surgery fasciotomy should be liberally used In cases of fracture associated with arterial occlusions stabilization of the fracture by internal fixation or Hoffmann transfixation, before arterial re

poor Relatively good results were achieved when the cause of loosening was trauma or malpositioning of the prosthesis (12 good or fair, 6 poor results) Poor results were achieved with infected or dislocated hips Our experience of the use of a cement mixed with gentamycin and massive antibiotic treatment in the reapplication is limited so far Without these precautions a *simple excision is indicated in infected hips*

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Physical examination demonstrates hypermobility in the hips tenderness on palpation posteriorly laterally and anteriorly over the hip joint and tenderness of the adductor muscle and pedes anserinae

Pauwels' technique endeavours to obtain better conditions of load in the hip joint thus preventing pain and osteoarthritis

COXA VALGA TREATED BY VARISATION OSTEOTOMY *AD MODUM* PAUWELS

H Glastrup
Stege, Denmark

Pauwels' technique has been modified to avoid hip plaster A wedge of approximately 20° is excised between trochanter major and minor the base medial anterior, the apex lateral posterior The osteotomy is fixed with a children's nail and Hubbard s plate by means of 3–4 screws

67 hips have been operated upon in 54 patients, 21–63 years of age One *died* 6 weeks after the operation due to pulmonary emboli and two later of unrelated disease

The subjective condition at follow up was excellent and good 40 fair 6, poor 5 The clinical condition at follow up was excellent and good 40 fair 8 poor 3 Radiographic examination of the 67 hips demonstrated excellent and good 57 fair 5, poor 5

The longest observation period was 13 years Long term observation ought to be 20–40 years

DISLOCATION OF THE HIP IN MYELOMENINGOCELE

Cato Hellum
Oslo, Norway

The main reason for hip dislocation in myelomeningocele is muscular imbalance *This is* especially liable to occur at level L_3–L_4 At this *level there are active hip flexors* and adductors and paralysed extensors and abductors Treatment aims at restoring muscular balance This can be done by transferring m iliopsoas *to* trochanter major *ad modum* Sharrard Forty three hips (29 patients) have been operated on in this way over the last 10 years

The results were as follows the caput in a good position in 16 hips improvement but dysplasia/subluxation in 11 hips failure (luxated as before) in 13 hips and in three hips the observation time was less than 6 months

The results are mediocre if considered from a purely dislocation of the hip point of view However, in this severely handicapped group of patients the following points should be emphasized All patients have major paresis and *gluteal insufficiency All* use *splints* and crutches None has pain Most important are the contractures found both in dislocated as well as in nondislocated hips Thus, hip dislocation is of relatively little importance Moreover these pa

tients have paralysed legs pressure sores urinary incontinence threatening hydrocephalus and social problems They constantly require follow up or treatment

Iliopsoas transfer should be done at an early stage preferably within 1 year Later nothing more than the correction of contractures is advocated

BONE SCINTIGRAPHY IN CALVE LEGG PERTHES DISEASE

O J Fasting N Langeland I Bjerkreim L Hertzenberg & K F Nakken
slo Norway

^{99m}Tc pyrophosphate was used to study cir ulation and metabolic activity in the femoral head in CLP The material comprises 35 patients having CLP at different stages

In the early stage when X ray showed only minor changes the scintigraphic picture dis closed reduced activity in parts of the femoral head Later in the course of the disease areas were found with increased activity and in the final stage a normal distribution of radio activity was observed

The method seems helpful in the diagnosis and in the study of the course of CLP

FEMORAL OSTEOTOMY IN COXA PLANA

S Friberg B Lundius T Persson B Tillberg & J Aström
Umeå Sweden

The radiographic results after femoral de rotation and varisation osteotomy in coxa plana were evaluated in 47 hips These results were compared with those obtained after conservative treatment (Thomas splint) in 45 hips The material was grouped according to the primary degree of necrosis of the epiphysis (Catterall 1972

The evaluation of the epiphyseal and joint surface quotients showed that no differences in

[illegible]

[illegible] ecn these two parameters and the primary degree of necrosis

The influence of type of treatment, age sex side and primary degree of necrosis on the re sults, derived from a general assessment of the radiographs (Table 1) was evaluated by step wise regression analysis This analysis showed that the degree of primary necrosis was highly correlated to the results ($P < 0.001$) A weak correlation was found to age ($0.05 < P < 0.01$) No correlation existed between the results and type of treatment sex or side

Table 1 Results derived from a general assess ment of the radiographs

	Osteotomy Degree of necrosis			
	1	2	3	4
Good	100%	35%		
Fair		61%	50%	43%
Poor		4%	50%	57%
No of cases	2	26	12	7
	Thomas' splint Degree of necrosis			
	1	2	3	4
Good	100%	44%		
Fair		56%	67%	33%
Poor			33%	67%
No of cases	8	16	12	9

ARTERIAL INJURIES CAUSED BY BLUNT TRAUMA OF THE EXTREMITIES ASPECTS OF DIAGNOSIS AND TREATMENT

Tor Hierton & Åke Hjelmstedt
Uppsala Sweden

The purpose of this report based on 25 "orthopaedic vascular cases" is to emphazise the importance of early recognition of ischaemia in cases of blunt non penetrating trauma to the extremities Arterial spasm without damage to the arterial wall is extremely rare The attitude of wait and hope for spontaneous improvement is dangerous Treatment with sympathetic block is a waste of time Preoperative arteriography is useful if performed without delaying the arterial repair In traumatic arterial occlusions due to blunt trauma (compression dislocation fracture) rupture of the intima followed by an occluding thrombus is a frequent mechanism. The aim is to restore a pulsative arterial flow in the injured artery within 6–8 hours Re section of the injured arterial segment and reconstruction with autogenous reversed vein graft end to end is the method of choice If too small a resection is performed followed by direct arterial suture under tension reocclusion is apt to appear Loss of distal pulses in the post operative period demands immediate re explora tion If massive swelling is present preopera tively or develops during or after surgery fasciotomy should be liberally used In cases of fracture associated with arterial occlusions stabilization of the fracture by internal fixation or Hoffmann transfixation before arterial re

pair, has advantages Saving the limb from permanent damage can be achieved by early arterial restoration and subfascial decompression Apart from the extent and level of injury, time lag is the most critical single factor Injured extremities should be carefully observed as regards distal circulatory status and function

ATLANTO-AXIAL INTERLAMINAR FUSION

K Harry Sørensen & Jakob Husby
Odense, Denmark

At the departments of neurosurgery and orthopaedic surgery in Odense, 36 patients have had atlanto axial interlaminar fusion in the period November 1966 to April 1975, carried out as a team effort between the neurosurgeon and the orthopaedic surgeon and with a specially developed technique Specially shaped bone grafts from the iliac crest with grooves for the two laminae and a graft for the right and the left side are fixed with wire

Twenty one patients had a fracture of the dens axis, five of them with pseudoarthrosis Ten had atlanto axial instability caused by rheumatoid arthritis and seven a horizontal instability with a distance of 12 mm from the dens to the anterior arc of the atlas Five had a vertical dislocation with the apex of the dens 8 mm cranial to foramen magnum Eight had medullary symptoms Two patients had os odontoideum with trauma and instability, and three had other lesions All fusions were solid at follow up at least 1 year after the operation All fractures had healed except one Great relief from symptoms was achieved with a minimum of restriction of movement of the cervical spine

OCCIPITOCERVICAL AND ATLANTOAXIAL FUSION IN CHILDREN

S Ryoppy
Helsinki, Finland

This material consists of four cases, two with congenital deformity and two with a traumatic aetiology The age at the beginning of symptoms was 7–9 years and the time between the beginning of symptoms and operation was 5–10 months Indications for operation were tetraparesis (one patient), inability to open the mouth and painful neck (one patient) and painful torticollis with restricted movement of the neck (two patients) Both patients with a traumatic lesion had a fixed rotary atlantoaxial luxation

The operation was performed in skull traction Three patients were treated with occipitocervical and one with atlantoaxial fusion The postoperative treatment consisted of skull traction for 4–6 weeks followed by a brace for 8 1 weeks Fusion of the intended area was achieve in all cases

The time of follow-up was from 2 to 3 years All patients were free of subjective symptom and pursued normal activities The posture wa almost normal in all The movements wer moderately restricted in one patient with severe atlantoaxial luxation and tetraparesi before operation In the other three the flexion extension and rotation were restricted by 10-2 per cent and the lateral bending by slightl more

It is concluded that occipitocervical and atlantoaxial fusion in the age group 7–10 years is a safe procedure with little risk and surprisingly little restriction of movement

RECURRENT POSTERIOR SHOULDER DISLOCATION TREATED BY THE TRANSPOSITION OF PECTORALIS MINOR TO THE ANTERIOR BICIPITAL RIDGE

Arne Rugtveit
Oslo, Norway

Results indicate that the treatment of recurrent posterior shoulder dislocation has generally been less successful than that of the corresponding anterior dislocations The need for a better operative procedure is therefore evident From a functional viewpoint, transposition of pectoralis minor from the coracoid process to the proximal portion of the anterior bicipital ridge should have a favourable effect in counteracting the tendency for a posterior dislocation The transposed muscle will exert a force directed antero medially on the humerus opposite to the *direction of dislocation* In addition on progressive internal rotation of the shoulder joint it will act with increasing effect as an external rotator, a role that is decidedly beneficial in this case since internal rotation is one component of the shoulder movement known to provoke a posterior dislocation

The author has used this method for treatment of recurrent posterior shoulder dislocation in four cases Two of these were traumatic in origin while two were habitual in nature Observation time was from 6 months to 3 years The results were good in all cases with no recurrence of the dislocation in any of the patients The method is extremely simple and the author cannot find any previous reports of its use for treating recurrent posterior dislocations

NEEDLE ARTHROSCOPY UNDER LOCAL ANAESTHESIA

K Buring & F Lund
Malmo Sweden

Arthroscopy under general anaesthesia is being used with increasing frequency as a routine method to establish the diagnosis after knee trauma This may cause an increased burden on the facilities of the operating theatre Sports medicine is an area where it is most important to establish a fast and correct diagnosis and needle arthroscopy under local anaesthesia is of great value In 72 patients arthroscopies were performed with 1 7 mm or 2 2 mm needles and after gaining initial experience with the technique good visualization of the knee pathology was obtained Multiple puncture using [illegible]terolateral posterolateral and posteromedial [illegible]pproaches has added valuable information

ULNAR NEUROPATHY AT THE ELBOW

[illegible] Reikerås
Oslo Norway

During the period 1961 1975 31 men and 24 women were treated for ulnar nerve palsy at Kronprinsesse Märthas Institut Oslo The age range was from 16 to 78 years Thirty four nerves on the right arm and 27 on the left were operated on with anterior transposition

The neuropathy was secondary to trauma or disease at the elbow in 35 cases and primary with a normal elbow in 26 cases At operation it was found that the neuropathy was due to fibrous compression in 30 per cent and to hypermobility in 21 per cent In 43 per cent there were no macroscopic reasons for neuropathy

The result in 51 patients in the mean 5 2 years after the operation was excellent in 47 per cent good in 30 per cent unchanged in 12 per cent and poor in 11 per cent The result was independent of duration of symptoms before the operation and independent of the surgical findings at operation The result was the same whether the nerve at the transposition was placed intramuscularly or subcutaneously

INGUINAL PAIN IN ATHLETES

A Buring
Malmo Sweden

[illegible]in pain sometimes with femoral radiation is a frequent complaint in a sports clinic Often the underlying cause may be an adductor tendinitis or a partial rupture of the quadriceps muscle and does not pose any major diagnostic problem From a differential diagnostic standpoint our interest has been focused on three more rare conditions 1) entrapment of the ilio inguinal nerve 2) entrapment of the femoral nerve 3) atypical hernias of the abdominal wall visualized by herniography

In the first instance excessive training of the abdominal muscles by sit ups and straight leg rising may cause strangulation of the ilio inguinal nerve in its zig zag course through the abdominal wall When a conservative approach fails symptoms are relieved by exploration The pain distribution often mimics that of an adductor tendinitis In the second instance three patients with long standing pain in the groin and weakness of the thigh during activity (soccer or ballet dancing) have been explored and strangulation of the lateral branches of the [illegible]ed The individual variations

nosis were demonstrated by herniography Positive contrast media was introduced intraperitoneally (by a technique of Ake Gullmo M D Helsingborg Sweden) A direct relation to a tear of the m abdominis transversus was noted in two cases

MORTON'S METATARSALGIA—A FOLLOW UP STUDY OF OPERATED PATIENTS

R Larsson
Goteborg Sweden

The material comprised 46 patients operated upon for Morton's metatarsalgia in the period 1966–1975 Four patients had been operated bilaterally The results were evaluated at least 6 months postoperatively(½ 9 years) and in 40 patients after more than 1 year The results are based on a review of the records answers to a questionnaire and follow up examinations in cases with persistent or recurrent discomfort of some importance

Six patients had been reoperated upon three of whom were considered cured after reoperation One had too short an observation time A total of 9 out of the 50 feet had discomfort of some importance Five out of nine had characteristic pain and were considered for reoperation Four of these five had been operated upon under local anaesthesia

Recurrence after operation seem to occur to a considerable extent Reoperation can cure and should be considered in patients with recurrent discomforting Morton pain Detailed symptom analysis is needed for correct preoperative diagnosis A thorough excision of the neuroma is probably of great importance for good therapeutic results General anaesthesia and tourniquet is recommended Pathoanatomical diagnosis is recommended to verify the diagnosis

CHONDROCALCINOSIS AS A SECONDARY PHENOMENON

Bjarne Lindén
Malmo, Sweden

The frequency of radio opaque deposits in joints and semilunar cartilages—chondrocalcinosis—was studied in various conditions In normal knee joints the frequency was about 1 per cent In patients treated for osteochondritis dissecans in the femoral condyles in childhood the frequency of chondrocalcinosis was not increased above normal However, in no less than 26 out of 41 patients, operated on in adult age for osteochondritis dissecans, chondrocalcinosis was found at a radiological follow up 25–55 years later The same follow-up of cases operated on for torn semilunar cartilages yeilded 14 cases of chondrocalcinosis out of 41 patients In patients with gonarthrosis no chondrocalcinosis could be found in the initial radiogram, the one that gave the diagnosis However, 10–18 years later 1/5 had radiological signs of chondrocalcinosis

THE BLOOD ALCOHOL CONCENTRATION AMONG TRAFFIC CASUALTIES

Jorgen Hogh & Inger Guldholt
Arhus, Denmark

Among 5,904 consecutive acute injuries over a 3 month period traffic accidents were responsible for 339 On arrival at the casualty department a blood sample was requested from all traffic injured persons for the measurement of alcohol concentration Some refused to attend the investigation and we have excluded all cases in which the blood sample was taken more than 2 hours after the accident The final material then consisted of 200 drivers and 53 passengers and pedestrians

The investigation showed a positive alcohol reaction in 34 5 per cent Of the drivers 155 per cent had more than 0 1 per cent alcohol in their blood The 15- to 19 year olds formed the greatest risk group but the maximal influence of alcohol in accidents was in a 10 year older age group Alcohol related accidents took place first and foremost during leisure time Of the male drivers 25 per cent had a more than 0 1 per cent blood alcohol content but no female drivers reached that level Of the drivers who sustained accidents between 9 30 p m and 3 30 a m, 61 per cent had more than a 0 1 per cent blood alcohol content, whereas in the daytime only 5 per cent had this level The police had only registered 25 per cent of the slight injuries and 42 per cent of the more severe injuries. Therefore, the police and in that way official statistics were only acquainted with 22 per cent of accident drivers having had more than 0 1 per cent alcohol in the blood

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PROCEEDINGS OF THE SWEDISH ORTHOPAEDIC ASSOCIATION

EDITOR BO E NILSSON

Lund, May 20–21, 1976

ARTHROPLASTY OF THE KNEE

A Ahlberg & B Lindén
Malmö

One hundred and thirty nine cases of total knee replacement were re investigated Improvement was recorded in 86 per cent of the osteoarthritis and 94 per cent of the rheumatoid cases The range of motion increased or remained unchanged in the osteoarthritis cases but was always improved in the rheumatoid cases Knee extension was improved particularly in the rheumatoid cases Five cases of mechanical loosening and two of infection were recorded

[illegible]

[illegible] & G Andersson
Gothenburg

Results were presented of 43 knee arthroplasties using the Freeman Swanson knee prosthesis Thirty two patients had rheumatoid arthritis 8 had gonarthrosis and 3 were operated on bilaterally All patients were studied preoperatively and postoperatively at fixed intervals of time the follow up varying from 6 to 48 months Sixty eight per cent were rated as good (pain free walking outdoors range of motion 10° to 90° stable and with varus or valgus deformity of less than 10°) Thirty per cent were improved and satisfied and only 2 per cent (one patient) rated as poor The complications included 1 deep thrombosis and 2 temporary peroneal nerve paralyses Three joints remained unstable but only one had to be re-operated on

KNEE ARTHROPLASTY ACCORDING TO GUNSTON HULT

H Henriksson & I Hult
Stockholm

Out of 18 cases operated on with the original Gunston prosthesis 12 were improved two mechanical loosenings and two infections were noted and dislocation or subsiding of the prosthesis was observed in three cases The Gunston Hult modification was used in rheumatoids mostly as a double demi prosthesis whereas osteoarthritic cases were operated on mostly with a medial demi prosthetic replacement Fifty five out of 62 patients were excellent or good the results being slightly better in osteoarthritis unimproved patients usually had complications of some sort such as subsiding in two cases loosening in two and infection in one Femoro patellar osteoarthritis appeared to be of little importance

AN UNUSUAL COMPLICATION IN THE FREEMAN SWANSON PROCEDURE

G Frykman
Västerås

A 60 year-old woman with rheumatoid arthritis was operated on using the Freeman Swanson procedure The operation succeeded technically but after 20 days instability was noted The distal end of the femur was displaced medially in relation to the tibia Later when instability increased the patient was re-operated on There was a complete rupture of the medial collateral ligament in the femoral attachment and a partial rupture of the collateral ligament. The prosthesis was removed and replaced by a hinge prosthesis with good results

THE HYPOPERFUSION SYNDROME IN KNEE ARTHROPLASTY

H Edfeldt & L Lidgren
Lund

Hypotension and hypoxaemia have been reported to occur as peroperative complications in intramedullary implantation of endoprostheses in the knee and the hip It has been claimed that these complications are caused by the insertion of cement and prosthesis into the marrow cavity Preliminary results of operations

with the Marmor procedure indicate that such complications may be seen even if the marrow cavity is not involved

SCINTIMETRY AS A DIAGNOSTIC MEANS IN SUSPECTED INFECTION OF TOTAL ARTHROPLASTY OF THE KNEE JOINT

G Jonsson I Lidgren & I O Sjöstrand
Lund

A high infection rate (50 per cent) was recorded in 15 patients with osteoarthritis operated on with the Guépar total hinge prosthesis Pre, per and postoperative antibiotic prophylaxis markedly reduced the infection rate Scintimetry could be used in diagnosing the infection and in assessing the effect of antibiotic treatment

PROSPECTIVE SURVEY OF ENDOPROSTHETIC ARTHROPLASTY OF THE KNEE IN SWEDEN

G Bauer, M Grubor & A Lindstrand
Lund

All departments of orthopaedic surgery in Sweden a total of 34 units have agreed to participate in a collaborative prospective study of endoprosthesis arthroplasty of the knee In each case a form will be completed on discharge and submitted to a central agency together with copies of pre and postoperative X rays On the original form early complications will be reported After discharge, all complications will be reported The agency will report at regular intervals on types of complications with relation to diagnostic groups and types of endoprostheses As the number of knee arthroplasties performed in Sweden increase the total number of operations reported should reach about 10 000 in 6 to 7 years

BONE CHANGES AND BONE HEALING AFTER RIGID OSTEOSYNTHESIS

P Slätis
Helsinki

The application of a rigid plate on diaphyseal bone in rabbits caused a change of cortical bone into trabecular Because of osteoclast activity a considerable porosity occurred in about 3 weeks The resorption cysts increased and after 12 weeks a confluence of the cysts was noted The torque breaking strength decreased by 40 per cent The bone grew wider because of subperiosteal apposition A similar pattern was seen after osteotomy or fracture Healing usually occurred after 9 weeks Compression did not speed the healing process

SECONDARY OPERATION OF FRACTURE OF THE ANKLE JOINT

S Olerud
Stockholm

Shortening and outward rotation of the fibula is the most common cause of osteoarthrosis after ankle fractures Late reconstruction of the talo fibular joint can be obtained by clearing the syndesmosis of fibrous tissue as well as lengthening and derotating the fibula after osteotomy This procedure also tightens the anterior fibulo talar ligament Dorsiflexion is usually improved

SCINTIMETRY OF PATELLAR OSTEOMYELITIS

G Hallin & N Nylén
Falun

A case of patellar osteomyelitis in a young boy was described A scintimetric study with technetium EDPH revealed a decrease of the uptake in the affected patella at an early stage the uptake later on being increased above normal and finally becoming normal This early decrease in uptake may be related to a relative avascularity of the patella during the first acute phase

SCINTIMETRIC STUDY OF OSTEOCHONDRITIS DISSECANS IN THE FEMORAL CONDYLES

B Lindén
Malmo

The uptake of ^{85}Sr was studied in 12 cases of osteochondritis dissecans in the femoral condyles of young adult men There was an increased local uptake of tracer close to the lesion but not in the rest of the joint The uptake was considerably less than in localized changes due to osteoarthritis or osteonecrosis

THERAPEUTIC ARTHROSCOPY

N Oretorp J Gillquist & G Hagberg
Linköping

In a series of 700 arthroscopies 40 per cent of the cases had to have arthrotomies However in cases of loose bodies in certain semilunar cartilage lesions and for the removal of sutures after cruciate ligament repair arthroscopy can be used therapeutically Loose bodies less than 4 mm can be flushed out larger bodies may be removed using a stone basket With this technique bodies larger than 2×1 cm were removed The knee function was completely restored 3 to 4 days postoperatively with full ability to participate in competitive sports

EXPERIENCE OF THE ACUTE MANAGEMENT OF SPINAL CORD INJURIES
(Guest lecture)

M Weiss
Konstancin, Poland

A review of 3 500 spinal cord injury cases was made at the Konstancin Rehabilitation Institute in Poland Immediate operative treatment for total paralysis with or without instability has been suggested for the last 6 years Special springs are used to accomplish reduction and stability In unstable fractures an autograft of iliac crest bone is used Postero lateral approaches can be performed after the stabilization in order to remove disc protrusions Caution indications are advised in non-complete cases

no-one knows how great the damage to the cauda equina is Surgery decreases the risk of secondary changes Stabilization of the fracture improves the breathing of the patient and excludes venostasis Springs are the best devices for fitting into the sphere between transversal and spinous processes

A NEW CONTRAST AGENT FOR MYELOGRAPHY

S Cronqvist
Lund

Amipaque is a new ionic water soluble contrast medium suitable for examination of the subarachnoid space and the whole spinal canal No spinal anaesthesia is needed The size of the cord can be easily evaluated and roots and root sleeves are well demonstrated offering increased diagnostic information in the cervical and lumbar regions Adverse reactions seem to be less frequent and definitely less pronounced than with pre-existing agents No irreversible side effects—arachnoiditis—have been recorded

REHABILITATION OF SPINAL CORD INJURIES IN SWEDEN

A Stenram
Lund

There is a considerable risk of secondary neurological injury during the *initial handling* of patients with spinal cord injuries Transportation under ideal conditions *directly to a* spinal cord unit is to be *preferred A helicopter* flight provides less stress on the injured patient than rapid ground transportation Surgery is indicated particularly in cases with progressive neurological *injury The Cloward* operation may be useful in immobilization of the cervical spine and at other levels surgery may also help in the early mobilization of the patient Experimental data indicate that one should continue to try steroids in the early treatment of spinal cord injuries

LASER IN ORTHOPAEDIC SURGERY

H Horosovski
Tel Hashomer Israel

In laser surgery the coagulation effect is particularly useful. The laser radiation may be used in tumor surgery and joint surgery In applying the method on Ewing sarcoma and osteogenic sarcoma the cutting and the devitalizing effect of the laser beam is used. The hemostatic effect is its greatest advantage in joint surgery Cutting of bone with the laser beam may cause healing difficulties and compression osteosynthesis is therefore advised in such cases The surgical procedure may be com*plicated* with skin burns Postoperative pain is reduced The most important use is in tumor *surgery* and in hemophilia surgery It is also valuable in arthrolysis and joint replacements but is still questionable where surgery on the *fine* structures is involved

IS THERE AN INCREASING RISK OF FEMORAL NECK FRACTURE?

K Obrant
Malmö

The total number of femoral neck fractures is increasing in the city of Malmo in spite of a *fairly* constant population Until about 1968 the incidence and risk of fracture had also increased After that time however the risk has increased only in the age group over 80. However owing to the population distribution *of* the city there is still a continuing rise in the total number

ENDER NAILING OF TROCHANTERIC FRACTURES

M Nilsson
Stockholm

Eight hundred and fifty hips have been operated on since 1971 The experience is *positive* with few complications (4 per cent) The patients were mobilized on *the first day* the mean hospitalization time being 26 days

RE OSTEOSYNTHESIS OF FEMORAL NECK FRACTURE

C. Zetterberg L. Irstam & G Andersson
Gothenburg

Over five years, 10 per cent of more than 500 cases *of cervical* femoral neck fracture were re

osteosynthesized Most of the cases were of Garden's stage IV The primary reduction had in most cases been acceptable The indications were *penetrating* or sliding nail with or without fracture dislocation Only 22 per cent of the *re osteosynthesized cases healed whereas the re*mainder showed signs of pseudarthrosis or necrosis all without relation to the fracture type

WHEN IS A CONTROL VISIT NEEDED AFTER HIP FRACTURE IN THE ELDERLY?

E Liedberg
Lund

Almost 250 patients with hip fractures are treated in Lund every year From 1972 to 1975 34 patients were treated for complications Only in one third of the cases were the complications *suspected at regular follow up examinations* Patients with complications have severe pain and seel medical advice Regular follow up with radiograms is recommended on three occasions only postoperatively, after 10 days and after *4 months*

SCINTIMETRIC STUDIES FOR THE EARLY DIAGNOSIS OF FEMORAL HEAD NECROSIS

G Baur R Brümmer, M Gustavsson
L I Hansson W Mortensson & L O Sjostrand
Lund

Eighty four patients were studied with ^{85}Sr scintimetry Forty healed without complications Forty four were complicated in one way or an other The uptake in the femoral head normally drops slowly after the fracture whereas those with complications maintain a significantly *higher uptake In a prospective series of 29 pa*tients, measurements were taken with a digital step scanning technique at short intervals after surgery During the first two months after surgery the uptake of ^{85}Sr could not predict complications whereas after 4 months the uptake was correlated to the clinical course and to complications

FRACTURES OF THE ACETABULUM—A FOLLOW UP OF 100 PATIENTS WITH 101 FRACTURES

O Lansinger & I Goldie
Gothenburg

Out of 66 patients with *central fractures* 61 were treated conservatively and 5 surgically Of the conservatively treated patients there was no central dislocation of the femoral head in 30 cases and the result for these patients was excellent–good in 90 per cent In 15 patients with central fracture dislocation the fracture in volved the inner acetabular wall and the result for these patients was excellent good in 87 per cent However, in *those 16 patients with fra*ctures of the acetabular roof the result was only excellent-good in 38 per cent Five patients were treated surgically 1 was good and 4 poor Of *35 patients with posterior fractures* 17 were treated conservatively with excellent good results in 82 per cent Eighteen were treated surgically with excellent–good results in 67 per cent

FUNCTION FOLLOWING REMOVAL OF TOTAL HIP PROSTHESES

G Gudmundsson, S A Ahlgren F Bertholdsson & I Hermansson
Skovde

Eleven patients were reviewed on average 2 years after the initial total hip implantation The implants were all removed due to infect on Three patients were working and all patients were improved with regard to pain as compared with their initial status Only one regretted the initial operation and none the removal of the prosthesis Five patients experienced we ght bearing pain and five experienced pain on resting One patient grossly overweight was mostly confined to a wheelchair Two could not *walk outdoors and another four felt* that the hip was unstable Ten of the patients had healed promptly, whereas one had recurring fistula for three months There was an average leg shorten ing of about four centimeters and three patients had an outward rotational malposition *Other*wise there was no fixed malposition There was a considerable difference between active and passive range of motion Two of the pat ents showed signs of mental depression needing psychiatric care

HEMODILUTION IN TOTAL HIP REPLACEMENT SURGERY

A Ahlberg A Nilius B Rosberg & A Udén
Malmo

Preoperative normovolemic hemodilution us ing dextran 70 was studied in a controlled ran domized group of patients *(n = 40) The pa*tients were drained of 1 5 litres of blood *The* control group were given 0 5 litre Macrodex® on the day of operation and on the third post operative day The total blood loss was not in creased by hemodilution In the hemodilution cases most of the blood was replaced by the patient s own Pulmonary emboli detected by lung scanning were more frequent in the control group and one patient died of pulmonary em bolization There were no serious complications in the hemodilution group The technique mar kedly reduced the need and risks of bank blood

and possibly reduced the rate of postoperative pulmonary emboli

QUADRILATERAL CAST BRACE IN FEMORAL SHAFT FRACTURES

S Mattsson
Umeå

Six fresh femoral shaft fractures and five femoral shaft fractures with delayed union were treated with a functional walking plaster cast The fractures were located on the two lower thirds of the femoral shaft The bracing was preceded by traction for about 2 months A brace moulded on the thigh was then used for another 2 to 4 months Within 7 months all cases were healed In fresh cases the range of knee motion became normal and there was no shortening of the leg In the cases of delayed un on the treatment was in 2 cases combined with a pseudarthrosis operation One infected case took 15 months to heal otherwise healing was observed to take place within 6 months There were no complications with this treatment

COMPARISON OF MENISCECTOMY IN IN PATIENTS AND OUT PATIENTS

A Stenström B Hagstedt & P Ljung
Lund

Half of the patients were operated on as out patients half were admitted to hospital for surgery There were no differences in the pre operative signs and symptoms in the two groups At the follow up there was no d fference in the n mber of postoperative out patient visits nor was there any difference in results between the two groups

THE POPLITEAL PTERYGIUM SYNDROME

L I Hansson K Jonsson A Stenström & K C Thorngren
Lund

A 74 year-old woman with this syndrome was

[illegible]

.. out of 10 sibl ngs and the father and paternal grandmother showed signs of the syn drome This is an autosomal dominant hered itary syndrome with incomplete penetrance and expression and with deformities such as popliteal pterygium equ nus foot osseous dys plasia syndactylia, perineal webbing hyper trophy of the clitoris hypotrophy of labia and uterus Hair pigmentation and growth deviations are also found These patients develop general arthrosis and spondylosis As, in this patient a greater than normal CE angle may be seen

A MODIFIED OSTEOSYNTHESIS ACCORDING TO RYDELL IN EPIPHYSEOLYSIS OF THE FEMORAL HEAD

L I Hansson A Stenström & K G Thorngren
Lund

A Rydell nail has been modified so that the inserted nail is attached to the femoral head proximal to the growth zone When the femoral neck grows the nail is pulled into the femur since the attachment proximal to the epi physeal line is maintained The method was successfully used for re operation of cases with slipping nails as well as in fresh cases

PSEUDARTHROSIS AFTER TIBIA OSTEOTOMY

B Tjörnstrand B Hagstedt & B Persson
Lund

Twelve cases with delayed union or pseud arthrosis after tibia osteotomy for gonarthrosis were re-operated on seven with resection of the pseudarthrosis reduction and Charnley com pression osteosynthesis one with a hinge pros thesis and the remainder by various methods Comparison was made between the preoperative status and the final status in these patients With regard to pain there was improvement with regard to walking capacity there was no change In most instances the required correction of the initial angulation deformity was obtained The cases described here represent 3 6 per cent of the total of a series of tibia osteotom es It is concluded that these cases should be re operated on and that the Charnley compression instru ment is useful for this purpose

AUTOTRACTION

S O Myrin
Taby

Thirty seven consecutive patients with signs of herniated disc were treated by autotraction in a collapsible portable traction frame—the Spina trac After an average of six treatments per pa tient 29 recovered completely six were much improved and one somewhat improved whereas one patient with obstructive arterial disease remained unchanged Thirty nine patients with backache without signs of disc herniation for at least one month were treated an average of five times Thirty-one recovered completely The frame has also been successfully used for cer vical traction and hip traction

LEFT SIDE PREDOMINANCE OF LUMBAR DISC HERNIATIONS

E Spangfort
Huddinge

Out of 2 504 lumbar disc operations 53 3 per cent were left sided regardless of the sex of the patient There was no left side predominance in cases with a negative finding at operation The predominance was less at more cranial levels of lumbar herniation It was not related to heavy work The left side predominance was highest in young patients and those under the age of 40 when disc herniation is most common This pattern was most obvious in cases with complete herniations

AN ORTHOPAEDIC OUT PATIENT SERVICE

H G Edeland
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Sixteen months of experience of the work in a separate out patient service attached to an orthopaedic department was presented In one year one surgeon treated 4 397 patients 210 of whom were operated on The ratio of first visits to return visits was 1 1

RADIOGRAPHIC ASSESSMENT OF DISLOCATION IN DISTAL RADIAL FRACTURES

S Friberg & B Lundström
Umeå

Radiography was performed in 40 wrists with fractures of the distal part of radius The effect of moderate rotation of the wrist and various directions of the central beam on the inclination of the distal radial joint plane in the lateral view was studied It was demonstrated at small differences in rotation of the wrist seriously altered the measured inclination of the joint plane when a perpendicular projection was used Angulation of the central ray 15° in a proximal direction significantly increased the accuracy of the examination

THE RADIAL TUNNEL SYNDROME

C O Werner
Lund

Symptoms similar to those of the tennis elbow may be caused by compression of the deep branch of the radial nerve A series of photographs of the operative findings in selected cases was presented

EVALUATION OF A MULTIFUNCTIONAL HAND PROSTHESIS CONTROLLED BY MYOELECTRIC PATTERNS

P Herberts & C Almstrom
Gothenburg

A promising approach to the control problem in multifunctional hand prostheses is the use of a pattern recognition technique in conjunction with a digital computer A portable control system for operating three bidirectional movements of a hand prosthesis based on the technique has been developed and adapted to the Swedish hand prosthesis which has sa active movements An added advantage is that the functional pattern may be studied with the computer The evaluation has shown that two amputees equipped with this control system were able to use all the prosthetic movements available

EFFECT OF GROWTH HORMONE AND THYROXINE ON CORTICAL BONE REMODELLING AND ON LONGITUDINAL BONE GROWTH

A Stenstrom L I Hansson & K G Thorngren
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Cortical bone remodelling along the femur diaphysis and longitudinal bone growth in the proximal tibia were determined in hypophysectomized and hormone treated hypophysectomized female rats aged 60 to 105 days with the tetracycline technique The hypophysectomized animals showed an increased periosteal resorption and an increased endosteal growth whereas the longitudinal bone growth increased Thyroxine increased the periosteal resorption but had no endosteal effect whereas the longitudinal growth increased

THE FRACTURE INCIDENCE IN 87 EPILEPTICS TREATED WITH DIPHENYLHYDANTOINE

A Walloe & L Lidgren
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The fracture incidence was studied in 87 patients with epilepsy In 7 years 34 of these patients had altogether 70 fractures 35 of which belonged to the group of fragility fractures Thirteen fractures occurred during epileptic seizures Even when the latter cases were excluded the risk of fracture in epileptic patients was calculated to be six times greater than the expected rate when age and sex were taken into account

cta orthop scand. 48, 241–244, 1977

CLEAR CELL SARCOMA OF TENDONS AND APONEUROSES

Report of Two Cases

KARI ALITALO, PEKKA PAAVOLAINEN, KAARLE FRANSSILA & VEIJO RITSILÄ

Division of Plastic Surgery, Helsinki University Central Hospital, and Department of Pathology, University of Helsinki, Finland

Two cases of clear-cell sarcoma of tendons and aponeuroses are reported The first patient was a 19 year old man with a tumor in the medial collateral ligament of the knee The tumor was enucleated, and after postoperative radiotherapy a wide local excision was done The patient was symptomless 4½ years after the operation The other patient was a man aged 68 with a tumor between the medial malleolus and the Achilles tendon He also received postoperative radiotherapy after enucleation Three months later a metastasis was noticed in the ipsilateral para iliac nodes The patient died 16 months after the operation The histology and clinical course of the two cases are analyzed Some integrative remarks based on earlier reports of 33 cases and the present two cases are presented

Key words clear-cell sarcoma, malignant tumor of tendons and aponeuroses, soft somatic tumor of the extremities

Accepted 21 I 77

CASE REPORTS

Case 1 A 19 year old man was admitted to hospital because of a tumor of the left knee He gave a history of two episodes of mild trauma to the knee during his military service, 6 and 2 months prior to admission After the second injury the knee was painful during exercise, and the patient discovered a small nodule on the medial side of the knee

[illegible]

medial side of the knee, which was thought to be a cyst of the medial meniscus At operation in March 1972 the medial meniscus appeared normal but a nodule about 1 cm in diameter was found in the medial collateral ligament This light brown tumor was easily enucleated Microscopy revealed a clear-cell sarcoma of tendons and aponeuroses.

The operated region was treated by tele-cobalt therapy (3116 R over a period of 24 days) followed by a wide local excision of the medial joint capsule During this operation, no signs of tumor were noted After 2 weeks, another dose of 3136 R for 3 weeks was given to the same area

A radio ulcer developed on the medial aspect of the knee The ulcer was closed with an abdominal tubed pedicle flap carried via the wrist and the right knee

When last examined in November 1976, 4 years and 7 months after the operation, no signs of metastases or local recurrences were observed

Case 2 The patient was a man aged 68 with a history of relapsing erysipelas on both legs One month before surgery he observed a firm movable nodule on the dorsal aspect of his right ankle During the following weeks the tumor grew in size, and the patient reported slight pain when walking There was no history of trauma to the ankle

On examination, a firm ovoid, movable mass, 4 cm in diameter, was palpated beneath the skin

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On examination both the function and X rays of the knee were normal The only finding was a small tender nodule under the skin on the medial side of the knee which was thought to be a cyst of the medial meniscus At operation in March 1972 the medial meniscus appeared normal but a nodule about 1 cm in diameter was found in the medial collateral ligament This light brown tumor was easily enucleated Microscopy revealed a clear-cell sarcoma of tendons and aponeuroses

The operated region was treated by tele-cobalt therapy 3116 R over a period of 24 days) followed by a wide local excision of the medial joint capsule During this operation, no signs of tumor were noted After 2 weeks, another dose of 3136 R for 3 weeks was given to the same area.

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Case 2 The patient was a man aged 68 with a history of relapsing erysipelas on both legs One month before surgery he observed a firm movable nodule on the dorsal aspect of his right ankle *During* the following weeks the tumor grew in size, and the patient reported slight pain when walking *There was no history* of trauma to the ankle

On examination, a firm, ovoid, movable mass 4 cm in diameter, was palpated beneath the skin

of the medial calcaneal region No destruction of bone could be demonstrated radiologically, and the function of the ankle joint was normal. *Clinically the tumor was regarded as a fibroma*

An extirpation was done in June 1974 The solid, well-demarcated tumor was situated between the medial malleolus and the Achilles tendon, with no invasion of surrounding tissue. It was surrounded by dense fibrous tissue. The lesion probably originated from the Achilles tendon sheath The tumor was light-brown colored, and the cut surface gave the impression of a benign fibroma or leiomyoma However, the histological diagnosis was clear-cell sarcoma of tendons and aponeuroses

Postoperative tele-cobalt therapy up to a tumor dose of 6000 R for 7 weeks was given Three months later lymphography demonstrated metastases in the right para-iliac nodes. This was verified histologically, and after extirpation the regional nodes were treated by a fotone dose of 5000 R for 2 months Thereafter, the patient was symptomless for 9 months He died in November 1975, 17 months after the diagnosis. At autopsy, bronchopneumonia and metastases in lungs and adrenals were found

HISTOLOGICAL FINDINGS

The staining methods used were haematoxylin and eosin, Weigert-van Gieson, Alcian blue, Periodic acid-Schiff reaction (PAS) with and without diastase, Gomori's reticulum stain, Gomori's method for iron and Fontana method for melanin

The microscopic examinations revealed the tumors to be non encapsulated, but their exact relation to the surrounding tissues could not be evaluated because both tumors had been removed by enucleation. The tumors were composed of solid nests and fascicles of cells surrounded by connective tissue septa The septa were mostly thin and delicate but sometimes the cell groups were separated by thick and dense fibrous areas (Figure 1) Reticulum fibers were seen around the cell nests, but they were scarce or absent between individual tumor cells (Figures 2 and 3) The tumor cells were either round or spindle-shaped The nuclei were large, pale-staining and round with prominent basophilic nucleoli *In case 1, some giant cells* with multiple uniform nuclei were observed Mitotic figures were few, about 1–4 per 10 high-power fields The cytoplasma was abundant and pale-staining, usually clear and often filled with tiny vacuoles (Figure 4) In case 2, small amounts of diastase-sensitive PAS negative material was found in the cytoplasm of some tumor cells No intra-or extracellular Alcian blue-positive mate-

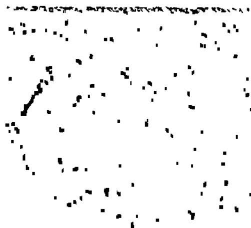


Figure 1. Clear-cell sarcoma Case 1 The tumor is composed of solid nests of cells surrounded by delicate connective tissue septa Also dense fibrous areas are seen between the nests (H and E, × 50).



Figure 2 Clear-cell sarcoma Case 1 Reticulum fibers surround cell nests (Gömöri's reticulum stain, × 50)

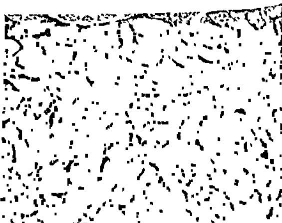


Figure 3 Clear cell sarcoma Case 2 Both thin reticulum fibers and thicker collagenous septae surround cell nests (Gomori's reticulum stain × 50)

rial was observed In both cases, both intra and extracellular iron was present, but no Fontana positive material was found The metastatic tumor in case 2 did not differ histologically from the primary tumor

DISCUSSION

The two tumors presented here fulfil the histologic criteria of the clear-cell sarcoma of tendons and aponeuroses presented by Enzinger in 1965 The most important of these criteria are the typical reticulum pattern, the clear cytoplasm of the tumor cells and the large pale nuclei with a prominent nucleolus Histologically it may be difficult to differentiate this tumor from synovial sarcoma, alveolar soft part sarcoma, chemodectoma, malignant melanoma, or metastasis from a clear-cell carcinoma The tumors presented here did not have the pseudoglandular pattern of synovial sarcoma Nor did the cytoplasm of the tumor cells reveal PAS positive, diastase-resistant granules typical of alveolar soft part sarcoma In chemodectoma, the septa surrounding the cell groups contain blood vessels, but these were not seen in the present cases Fontana-positive pigment, which is usually present in malignant melanoma, was not found in these two tumors Nor was any other tumor found in the skin or elsewhere which could have transferred metastases Consequently the histological diagnosis made seems to be correct

MacKenzie (1974) has described one and Bearman et al (1975) two clear-cell tumors originating from tendon which contained melanin pigment Electron microscopy showed melanosomes in the cases described by Bearman et al The tumors thus represented melanomas with an apparent soft tissue origin No melanin has been mentioned in the other reported cases In a case report by Hoffman & Carter (1973) the primary tumor showed the features of clear-cell sarcoma but in a recurrent tumor and in meta-



Figure 4 Clear-cell sarcoma Case 2 The nuclei are large and pale with prominent nucleoli The cytoplasm is clear and abundant and filled with vacuoles of varying size (H and F, × 150)

stases 3 years later melanin pigment was seen It is possible that some of the cases reported represent amelanotic melanomas

Although it is possible that clear-cell sarcoma of tendons and aponeuroses is not histogenetically a homogenous group it seems to be a rather homogenous group clinically Therefore, some integrative remarks based on earlier reports (Bennett 1947, Guichard et al 1968, Rousselot et al 1968, Kubo 1969, Vuillard 1969, Dutra 1970, Jung et al 1970) and the present two cases are presented here (a total of 35 cases, cases with melanin pigment were not included)

The median age of the patients at diagnosis was 32 years (range 12 68 years) Males and females were equally represented (17 males, 18 females)

At the time of the first operation, all tumors were solitary The diameter of the tumor varied from 1 to 6 cm The topographic distribution of the primary tumor is shown in Table 1

Metastases were observed in 18 of the 30 cases with a follow-up of at least 1 year They were located most frequently in regional lymph nodes and lungs, also metastases in bone, liver, heart and adrenals were observed The median interval between the first operation and

the occurrence of the first metastasis was 4 years (range 1 month to 30 years)

Clear cell sarcoma seems to be especially prone to recur, in the 30 cases with a follow-up of at least 1 year recurrences were observed in 20 cases This may be partly explained by the rather conservative surgical treatment due to the benign, well-demarcated appearance of the tumor at operation

Table 1 Anatomical distribution of the 35 clear cell sarcomas reported

Location	No of patients
Lower extremity	
Planta pedis	6
Achilles tendon	4
Knee	5
Ankle	4
Patellar tendon	3
Heel	1
Buttock	1
Toe	2
Upper extremity	
Finger	5
Palm	1
Forearm	2
Triceps	1
Total	35

The mortality rate in clear cell sarcoma is high, 18 out of the 30 patients with a follow-up of at least 1 year have died The actuarial 5-year survival rate was about 50 per cent Although the mortality rate is high the growth of the clear-cell sarcoma seems to be rather slow The duration of symptoms prior to the treatment was less than 1 year in 13 cases, 1 to 4 years in 11 cases and more than 5 years in 8 cases (maximum 19 years), no data were available for three patients Three deaths from cancer occurred more than 10 years after treatment (11, 12 and 36 years later)

Thirty two of the cases were primarily treated by local excision For 25 patients this was the only treatment during th first stage This treatment was followe by radical operations in 15 cases (ext r sive local excisions, 9 amputations) On 10 patients received radiotherapy Th different forms of therapy did not seen to differ in therapeutic value Howeve if local excision is not adequate, recu rence is the rule No significant differ ences appear between patients treat early or those treated after several recu rences

ACKNOWLEDGMENTS

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IETAL SENSITIVITY IN PATIENTS TREATED FOR TIBIAL FRACTURES WITH PLATES OF STAINLESS STEEL

EI CRAMERS & ULF LUCHT

Department of Dermatovenerology Marselisborg Hospital and
epartment of Orthopaedic Surgery Aarhus Amtssygehus Aarhus, Denmark.

In three patients a local dermatitis developed 3–3½ months after tibial osteosynthesis with plates and screws of stainless steel 316 L (AO) Two of the patients had a positive patch test for chromium (and cobalt) and one for nickel. Infection was not indicated and it is suggested that the dermatitis was caused by a metallic sensitivity The skin affection disappeared after removal of the metal

Key words dermatitis metallic sensitivity, stainless steel tibial fracture

Accepted 2 iii 77

Contact sensitivity to nickel, chromium and cobalt is well known although the incidence of skin sensibility to these metals in the general population is unknown Fregert et al (1969) have tested a group of 4 825 patients suspected of having various skin diseases and found the following frequencies of positive patch tests in the female/male patients nickel 10 2/1 8 per cent, chromium 3 6/10 7 per cent and cobalt 6 6/7 4 per cent A few cases of eczematous dermatitis caused by internal exposure to nickel have been reported (Fousserau & Laugier 1966, Barranco & Soloman 1972, Pegum 1974)

The aim of the present report is to draw attention to the possibility of local dermatitis caused by metal sensitivity in patients treated for tibial fractures with implants of stainless steel

CASE REPORTS

Case 1 A 19 year-old woman sustained an un

and eight screws (AO) of stainless steel (Figure 1) She was mobilized with crutches without weightbearing on her left leg 8 days after the operation and the postoperative period was uncomplicated Weightbearing was started 2 months after the operation One month later an erythematous and infiltrated area appeared on the skin overlying the plate and at the same time local pains occurred The roentgenograms showed no signs of reaction around the metal An infection was suspected and 2 weeks later an incision was made No pus was observed and no bacteria were found by culture The erythrocyte sedimentation rate was 9 mm/1 hour From these observations an infection seemed unlikely and some days later the metal was removed and the skin closed Skin healing was uncomplicated without use of antibiotics and the dermatitis disappeared The fracture healed after treatment with a plaster cast A patch test 2 months after removal of the metal was positive for chromium and cobalt. The reaction was strongest after 96 hours without a toxic reaction

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Cramers & Ulp Lucht

partment of Dermatovenerology Marselisborg Hospital and
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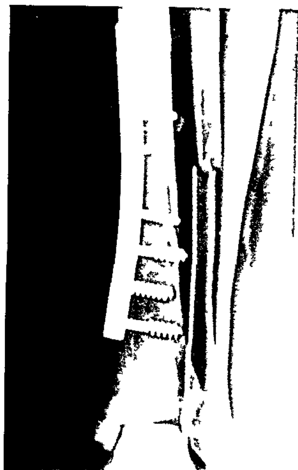


Figure 1 Case 1 Postoperative roentgenogram

A patch test 4 months later was positive f r chromium and cobalt The reaction was strong est after 96 hours without a toxic reaction

Case 3 The patient was a 46 year old wom who sustained an uncomplicated fracture of h right tibia and fibula after a fall from a tab The tibial fracture was fixed under compres with a plate and seven screws (AO) of stain steel (Figure 3) The postoperative period w uncomplicated Walking without weightbea on the right leg was started 7 days after t operation Three months postoperatively erythematous and infiltrated area appeared the skin overlying the plate and local pains o curred In the following weeks the symp varied in intensity and were reduced after period of relaxation The roentgenograms sh d no reaction around the metal At 3½ mon after the operation a bulla appeared in t erythematous area The first cultivation for b teria was negative but a second which was ma some days later showed staphylococcus aure The plate end screws were removed and the closed No pus was observed around the me and no bacteria could be cultivated from th

Case 2 A 19 year old woman sustained an open fracture of her right tibia and fibula after a fall from a horse The tibial fracture was fixed under compression with a plate and eight screws (AO) of stainless steel (Figure 2) The postoperative period was uncomplicated She started walking without weightbearing on her right leg 7 days after the operation and with weightbearing after 2½ months After 3½ months an erythematous and infiltrated area appeared on the skin overlying the plate and local pains occurred In the following weeks the symptoms varied in intensity They increased after a period of walking and decreased after a period of relaxation Five months after the operation a little bulla developed in the erythematous area No bacteria were found by culture The roentgenograms showed no reaction around the metal The plate and the screws were removed and the skin closed No pus was observed around the metal and no bacteria were found by culture The erythrocyte sedimentation rate was 7 mm/1 hour Skin healing was uncomplicated without the use of antibiotics and the dermatitis disappeared The fracture was treated with a plaster cast and healed without complications



Figure 2 Case 2 Postoperative roentgenogram

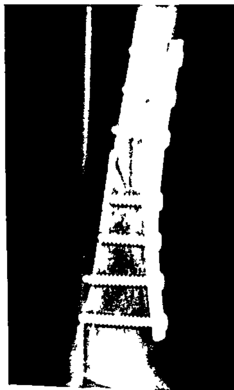


Figure 3 Case 3 Postoperative roentgenogram

surround ng tissue The erythrocyte sedimenta tion rate was 19 mm/1 hour The skin healed without ant biotics and the dermatitis disap peared The fracture was treated with a plaster cast and healed without complications A patch test at the time of removal of the metal was positive for nickel The reaction was strongest after 72 hours without a toxic reaction

None of the three patients referred to had any recognized metal hypersensitivity or eczema prior to the accident and there was no evidence of occupational exposure to metals

METHODS

Patch test

The following solutions of metals were used Nickel sulphate 5 per cent, potassium dichromate 0 5 per cent cobalt chloride 2 per cent manganese chloride 2 per cent ferri chloride 2 per cent sod um molybdenum 2 and 5 per cent all with petrolatum as vehicle The con centra ... the sa ... mittee ... Testing (Fregert et al 1969) Iron, mangano and molybdenum were used in the same concentra tions as used by Geiser et al (1960)

The patch test was placed on the back just below the scapula and left for 48 hours A read ing was taken 48 72 and 96 hours after the application The reactions were considered posi tive if erythema and infiltration with or with out papules or vesicles occurred

Analysis of the implant

The stainless steel (316 L) used for the present three patients contains chromium nickel molyb denum manganese iron carbon silicon sulphur and phosphorus but not cobalt

A portion of the stainless steel was rotated for 35 days in a Ringer solution at 37.8° C. The solution was subsequently tested by atomic ab sorption spectrophotometry for any dissolved metal Iron manganese and nickel were detected but not chromium The analysis was performed by the Division of Inorganic Chemistry Univer sity of Aarhus Denmark

DISCUSSION

The three cases described are rather similar and it is strongly suggested that the skin reactions were caused by metal sensitivity and not by infection Thus, the positive patch tests in combination with no previous known allergies and the disappearance of the skin reactions after the removal of the implant are consistent with metal sensitivity caused by the im plant The absence of bacteria after cul ture from the tissue around the plates, the normal sedimentation rates and the un complicated skin healing after the re moval of the plates argue against infec tion

A release of metal ions from an im plant requires a corrosion of the alloy Generally it has been believed that stain less steel implants have a high corrosion resistance However, the following re ports indicate that various metallic alloys currently in use in human beings, in cluding stainless steel, are exposed to corrosion Thus, Lüdinghausen et al (1970) made histological examinations in 50 cases treated by osteosynthesis with



Figure 1 Case 1 Postoperative roentgenogram

A patch test 4 months later was positive for chromium and cobalt The reaction was strongest after 96 hours without a toxic reaction

Case 3 The patient was a 46 year old woman who sustained an uncomplicated fracture of her right tibia and fibula after a fall from a table The tibial fracture was fixed under compression with a plate and seven screws (AO) of stainless steel (Figure 3) The postoperative period was uncomplicated Walking without weightbearing on the right leg was started 7 days after the operation Three months postoperatively an erythematous and infiltrated area appeared on the skin overlying the plate and local pains occurred In the following weeks the symptoms varied in intensity and were reduced after a period of relaxation The roentgenograms showed no reaction around the metal At 3½ months after the operation a bulla appeared in the erythematous area The first cultivation for bacteria was negative but a second which was made some days later showed staphylococcus aureus The plate and screws were removed and the skin closed No pus was observed around the metal and no bacteria could be cultivated from the

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Figure 2 Case 2 Postoperative roentgenogram



Figure 3 Case 3 Postoperative roentgenogram

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A release of metal ions from an implant requires a corrosion of the alloy Generally it has been believed that stainless steel implants have a high corrosion resistance However, the following reports indicate that various metallic alloys currently in use in human beings, including stainless steel, are exposed to corrosion Thus Lüdinghausen et al (1970) made histological examinations in 50 cases treated by osteosynthesis with

stainless steel (A I S I 316) and found some degree of metallosis in every case from 4–36 months after surgery Ferguson et al (1960) embedded different kinds of metallic implants in the spinal muscles of albino rats for 4–6 months In the muscles surrounding the metal they found, by spectrochemical analysis, metallic elements in concentrations which were significantly higher than in controls For stainless steel (A I S I 316) they found nickel, chromium, iron and molybdenum Cohen (1962) tested various metals *in vitro* under cyclic stresses similar to those encountered in clinical practice He used screws and plates and determined their weight loss after 10 million cycles Stainless steel (A I S I 316) had a higher weight loss than vitallium The most common site for the corrosion is the junction between components of implants (Scales et al 1959, Emnéus 1961, Cohen 1962) Scales et al (1959) believe that the anaerobic condition between countersinks of screws and screw holes is a cause of the corrosion which often occurs at this location

For the three patients in the present report the concentrations of metal ions in the tissue surrounding the implants has not been measured When the implants were rotated in a Ringer solution we found nickel, manganese and iron but not chromium The inability to demonstrate the last metal may be due to the conditions *in vitro* being different from those *in vivo* where cyclic stresses and changes in the oxygen tension affect the implant The present observations that the complaints of two of the patients were reduced after a period of relaxation and increased after a period of walking are consistent with a varied release of metal ions depending on variations in cyclic stresses and blood flow

The local dermatitis in our three patients is a delayed type (Gell & Coombs type IV) hypersensitivity (Lowney 1975) It is not possible to know with certainty if the patients were sensitive to the metal before the implantation This, however was not indicated by the anamnesis and the time sequence of events rather indicates that the implants induced the sensitivity The metal reaction in the present patients developed a relatively short time after the operation, but this may be explained by the close relationship between the implants and the skin The two patients who had positive patch tests for cobalt were presumably sensitive to this element at the time of the operation because stainless steel does not contain cobalt The disappearance of the dermatitis after removal of the metal is in agreement with other studies (Barranco & Soloman 1972, Fousserau & Laugier 1966)

Once acquired, specific sensitivity tends to persist but the degree of sensitivity may decline if the patient avoids contact with the specific allergen However, after re-exposure to the primary allergen the level of the sensitivity rises rapidly, and the patient may get a new allergic reaction It is important for the orthopaedic surgeon to be aware of this possibility, and in doubtful cases patch test the patient Titanium may be a satisfactory substitute if a positive patch test for nickel or chromium is found

The present report together with earlier studies (Fousserau & Laugier 1966 Barranco & Soloman 1972, Pegum 1974 Munro Ashman & Miller 1976) stress that if a skin reaction occurs some months after osteosynthesis a metal sensitization should be suspected In the case of metal reaction the symptoms will disappear after removal of the metal which should be performed under sterile conditions to avoid a secondary infection

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THE EFFECT OF IMPACT LOADING ON RABBIT KNEE JOINTS

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Eighteen mature male Whiteland rabbits received repetitive impulse loads slightly larger than body weight (4 kp) through one knee joint for periods from 1 to 6 weeks Mechanical compression of subchondral bone cores from impacted tibiae showed progressive increased deformation under a constant force Cartilage degeneration occurred concurrently with alterations in the mechanical properties of the subchondral bone The cartilage degeneration may be explained by (i) the deleterious effect of repetitive mechanical compression, (ii) the decreased mechanical support of the underlying subchondral bone

Key words subchondral bone, microfractures, fatigue, impact loading reflected light microscopy

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Despite a multitude of factors known to be responsible for the induction of both clinical and experimental degenerative joint disease, the etiology of primary osteoarthritis remains unsolved (Gardner 1960)

The attenuation across joints of forces resulting from impact loads has been shown to be a function of subchondral bone and soft tissue rather than cartilage or synovial fluid (Radin et al 1970) A current hypothesis concerning the etiology of degenerative joint disease proposes that microfractures occur in subchondral bone as a result of repetitive impact loads These lead to subchondral bone stiffening secondary to callus formation (Radin et al 1973) This stiffening of the subchondral bone presumably reduces its shock absorbing qualities, which then predisposes the overlying cartilage to degeneration

The purpose of this study is 1) to produce experimental degenerative joint disease secondary to impact loading and 2) to examine the changes occurring in the affected tissues, particularly the subchondral bone

MATERIALS AND METHODS

Loading machine

An experimental machine was designed which loaded the right knee joint of six rabbits simultaneously (Figure 1) Both legs were held in extension at the knee joint with plastic splints. The right leg of each animal was subjected to a 4 kp impulse load 56 times per minute for 1 hour daily The frequency and amplitude of the impact load were selected so as to simulate the work of Radin et al (1973) The left knee of each animal served as a control and was not loaded

A schematic drawing of how the cyclic impulse load was delivered is shown in Figure 2 The springs used to produce the 4 kp load were specially constructed to produce this force with 5 mm of deformation All springs were tested

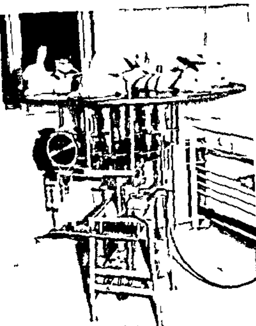


Figure 1 Six rabbits are shown in the impulse loading machine The right leg of each rabbit received a 4 kp load 56 times per minute The left leg was not loaded and served as a control

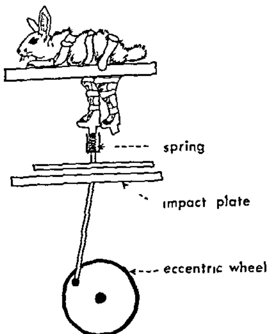


Figure 2 A schematic drawing showing how the impulse load was produced and transmitted to the right leg of each rabbit Special springs were constructed to produce 4 kp of force with 5 mm of deformation

for error prior to and at the completion of the experiment—this was found to be ± 1 per cent The height of the cylinders in which the springs were housed was made adjustable to accommodate anatomical variations in the rabbits legs

The relationship of force input to time is depicted by a dome shaped curve (Figure 3) The impulse load of each cycle started at 0 07 sec rose to 4 kp at 0 28 sec and then decreased to 0 kp of force at 0 49 sec The total duration of the impulse was 0 42 sec

The rapid rise and fall of this force time relationship was chosen to simulate clinical stresses occurring in the human knee joint while walking (Morrison 1970)

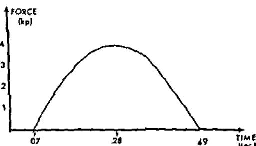


Figure 3 The dome shaped curve represents the force input into the right leg with each impulse load This impulse load occurred 56 times per minute for 1 hour daily The rapid rise and fall of the force input was selected to simulate joint loads which occur clinically

Animal selection

Eighteen male Whiteland rabbits weighing from 2 5–3 kg were divided into six groups containing three animals each Each group was then tested for time intervals from 1 to 6 weeks The knee joints of all animals were X rayed prior to testing to ensure skeletal maturity All animals were allowed free movement in their cages except for the 1 hour of daily impact loading

Experimental procedure

A general outline of the experimental procedure followed is shown in Figure 4

Tibial cores

At the completion of each week of loading, three animals were sacrificed and both knee

joints were disarticulated The proximal ends of the tibiae were then placed in plastic molds to fix the sites of the cores With a 5 mm trephine drill, under cooling irrigation, a core was removed from each medial tibial condyle The core was then machined in a turning lathe with an optical microscope attached to ensure complete removal of all cartilage A special chuck with a face-plate backing ensured that both surfaces of the specimen were parallel The length of the core was 3 ± 0 05 mm

Mechanical testing

An Alwetron testing machine compressed the tibial cores to a maximum of 1 kp of force (error ± 1 per cent) The rate of compression was 0 05 mm/min The deformation of each core was simultaneously read in a recorder and a load deformation curve was thus obtained (Figure 5)

Each sample was measured with a micrometer (± 0 01 mm) before and after testing The permanent deformation produced by the mechanical compression is recorded in Table 1

All samples were stored in normal saline at room temperature prior to testing The time interval from sacrifice of the animal to testing was approximately 6 hours

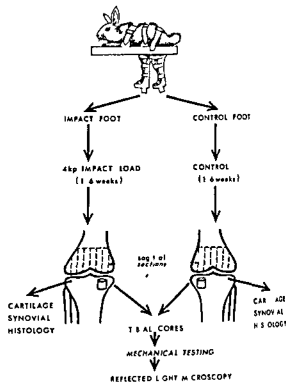


Figure 4 A schematic outline of the experimental procedure followed

Table 1 The mechanical deformation of the control and loaded tibial cores The permanent deformation produced by mechanical compression is recorded in column 8 and is measured in microns The higher incidence of permanent deformation occurring on the loaded as opposed to the control side should be noted

Rabbit	1 week		2 weeks		3 weeks		4 weeks		5 weeks		6 weeks		Perm def (μ)	
	contr	load	contr	load	contr	load	contr	load	contr	load	contr	load	contr	load
1	22 4	12 6											0	0
2	25 3	28 0											0	0
3	20 0	28 0											0	0
4			13 0	29 5									0	40
5			26 0	18 0									0	0
6			22 0	24 0									0	10
7					19 5	25 0							0	10
8					21 5	22 0							0	10
9					20 5	26 0							10	10
10							16 0	22 5					10	10
11							17 0	22 5					0	0
12							27 5	40 0					0	0
13									22 5	40 0			0	10
14									15 0	22 5			0	0
15									28 0	41 0			0	0
16											17 5	22 5	0	20
17											18 0	35 0	0	20
18											18 0	35 0	0	30

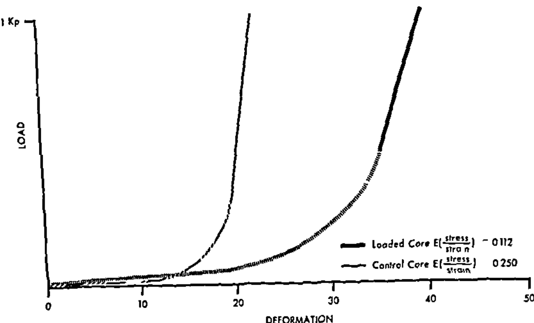


Figure 5 This is a graphic representation of the load/deformation curve obtained from the Alwet[ron] testing machine These curves refer to the control and impact loaded tibial cores from a rabbit subjected to 5 weeks of impact loading (see Table 1 rabbit 13) The units of deformation correspond to the squares of the actual graph paper output from the Alwetron These can be converted to absolute values (mm) by dividing by 324 The non linear portion (broken lines) of each curve represents the seating in of the core during initial mechanical compression The linear portion (solid line) of each curve depicts elastic deformation of the tibial cores By calculating the slopes of these solid lines we can then compare the relative modulus of elasticity or stiffness between the impact loaded and control cores

$$\textit{Control core}\quad \mathrm{E}\left(\frac{\text{stress}}{\text{strain}}\right) = \text{slope} = \frac{1\ \text{kilopond}}{22\,5 - 18\,5} = 0\,250$$

$$\textit{Impact loaded core}\quad \mathrm{E}\left(\frac{\text{stress}}{\text{strain}}\right) = \text{slope} = \frac{1\ \text{kilopond}}{40 - 31\,1} = 0\,112$$

The slopes of each curve are in load/deformation units Since each core was standardized for length and cross sectional area these values are directly proportional to absolute stress/strain units (i e modulus of elasticity)

Femoral condyles

The right and left distal femurs were cut sagittally to a depth of 15 mm and a thickness of 2 mm under cooling irrigation (Figure 4)

Histology

1) *Synovium* Synovial biopsies of both knees were fixed in 4 per cent neutral formalin and then stained with hematoxylin and eosin and van Gieson

2) *Cartilage* The lateral tibial condyles were fixed in 4 per cent neutral formalin decalcified in Parengy solution and stained with Tolidine blue at pH 0 5 and 4 0, hematoxylin and eosin and van Gieson

3) *Tibial cores and femoral slices* These samples were first defatted in solutions of ethyl alcohol and ether The liquid component of the bone was removed by vacuum drying The specimens were then embedded in epoxy resin (Araldit D*) under vacuum (Luft 1961) The specimens obtained were ground with wet silica carbide paper polished and then subjected to reflected light microscopy (Pugh et al 1972)

Limitations of present study

1) *Force input* Although the cylinders were adjustable to accommodate anatomical variations

* (Araldit D CY 230 Ciba)

in each rabbit leg, the error in force input could not be controlled to better than ± 500 g

2) *Tibial cores* The use of plastic molds standardized the size and angle for selection of each core from the medial tibial condyle Anatomical variations in the size of tibiae introduced an unavoidable error

3) *Permanent deformation* The amount of permanent deformation produced by compressing the bone with 1 kp of force is recorded in Table 1 (column 8) This deformation is produced by breaking the bone Artifactual cracks thus result from this testing procedure However, since our criteria of a true microfracture included the demonstration of callus breaks resulting from artifact would be excluded

RESULTS

1) *Gross examination of tibial cores*

The impacted tibial cores became more friable and developed a texture analogous to granular sugar as the experiment progressed These changes were not noted on the control side

2) *Mechanical compression of tibial cores*

Figure 5 is a graphic representation of the load deformation curve obtained from the Alwetron testing machine The deformation curves refer to the control and impact loaded tibial cores from a rabbit tibia subjected to 5 weeks of impact loading These curves allow the comparison of relative stiffness (modulus of elasticity) between an impact loaded and a control core The modulus of elasticity of the control core is 0 250 while that of the impacted core is 0 112 (Figure 5)

No significant difference was found between the impacted and control tibial cores in the first 2 weeks of loading (Table 1) This is attributable to the minimal difference in the average deformation values between the impacted and control groups (Sign and Walsh Test Siegel 1956) In the 3, 4, and 5 week groups

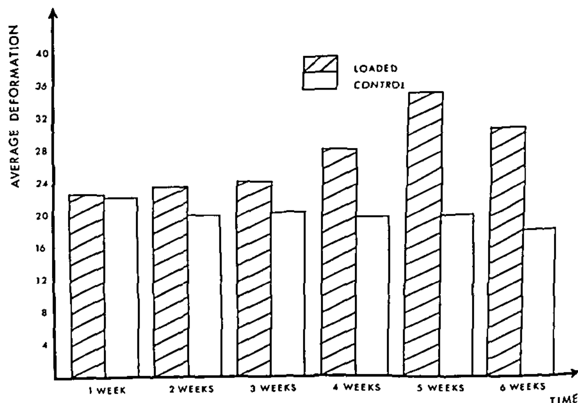


Figure 6 Bar graph showing the average mechanical deformation of the control and loaded tibial cores with time



Figure 7 Photomicrograph of a cancellous bone trabecula subjected to reflected light microscopy (× 50) This specimen is taken from a 3 week impacted tibial core The arrows show artifactual cracks produced either by the machining or the mechanical testing of the specimen Note the absence of callus A denotes the epoxy resin in which the specimen is embedded The dark diagonal lines seen crossing the specimen are artifacts produced during polishing

there were statistically significant differences between the impacted cores on a 1 6 per cent level

The mechanical deformations of the control and tested tibial cores at weekly intervals are also shown in Table 1 In all rabbits (except for rabbits one and five) the deformation observed in the loaded cores exceeded that in the control group As the cancellous bone became more deformable the mechanical deformation increased (Figure 5)

The average deformation of the tibial cores progressively increased over the 6 week period (Figure 6) The average deformation for the 1 3 and 6 week impacted group was 22 9 24 3, and 30 8 units

3) *Permanent deformation*

The amount of permanent deformation in the tibial cores following the 1 kp of mechanical force is recorded in Table 1 (column 8) Permanent deformation occurred in 12 of the 36 cores tested Of these, ten occurred in the loaded tibial cores, the remaining two in the control cores

4) *Reflected light microscopy of tibial cores*

Reflected light microscopy demonstrated numerous artifactual cracks to be present in all tibial cores These occurred either in preparation of cores or during mechanical compression

A cancellous core from a 3 week impacted tibia is shown in Figure 7 The crack in the trabecula is indicative of an artifact because it lacks callus formation A photograph of an impacted tibial core from a 5 week animal is shown in Figure 8 This crack is suggestive of a healing microfracture in that it displays periosteal swelling The lack of cellular activity is related to the preparation of the specimen

In general the number of artifac-

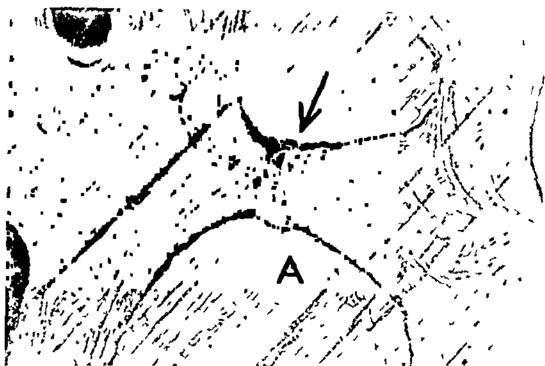


Figure 8 Photomicrograph of cancellous bone taken from a 5 week impacted tibial core (reflect light microscopy × 42) The fatigue fracture depicted by the arrow shows periosteal reaction i dicative of callus formation Note the lack of displacement at the fracture site

tual cracks occurring in the control tibial cores remained relatively constant throughout the experiment The impacted cores, however, tended to show an increase in artifactual cracks as the experiment progressed Trabecular fractures associated with periosteal reaction as depicted in Figure 8 were absent from the control cores and did not appear in any of the impacted cores until 2 weeks of loading It must be stressed, however, that their occurrence was rare and did not seem to increase with the duration of loading Of all the specimens examined, only two examples of the microfracture shown were found

5) *Reflected light microscopy of femoral slices*

The frequency of artifactual cracks on the control side remained constant while the loaded side showed a progressive increase of artifacts with time However, no evidence of fractures associated with callus formation were seen in any of these specimens

6) *Histology of synovial membrane*

A Gross After the first week of im pulse loading the impacted knees deve oped synovial effusions, which were pro gressive with time and associated wit gradual atrophy of the synovial mem brane and steady thickening of the joi capsule

B Microscopic examination The no mal synovial membrane has a loose con nective tissue stroma (Figure 9) and th first changes in the experimental synovi membrane occurred in this stroma Th loose stroma was gradually replaced b cellular connective tissue with collage fibers (Figure 10) A progressive increas in capillary vessels in the synovial vil occurred and in some areas there wa hyperplasia of the synovial epithelium In all impact loaded rabbits, by the 6 week period, foreign body giant cell were seen in the synovial stroma an pericapsular tissue (Figure 11) Va Kossa stain revealed that some of thes giant cells contained calcium

The synovial membrane of the contro

side remained normal both grossly and microscopically

7) *Histology of articular cartilage*

A Gross The impacted articular cartilage of the tibia and femur showed a gradual loss of the glistening, shiny, blue white appearance of normal cartilage Changes were noted by the end of the first week of testing and there was a gradual progression to a non glistening, yellow, fibrillated surface accompanied in the later stages with lipping of the joint margins

No changes were noted in the control knees

B Microscopic examination Histological examination with hematoxylin and eosin and Tolidine blue at pH 0 5 and 4 0 failed to reveal any appreciable abnormality in the first 2 weeks of loading

At the completion of the third week, examination of the periarticular cartilage showed derangement of the columnar pattern of cartilage cells Fibrillation of the articular cartilage characterized by disruption of the matrix with cleft formation and deletion of ground substance, as revealed with Tolidine blue stain, was also noted (Figures 12 and 13)

Increased vascularity of the subchondral bone was accompanied by invasion



Figure 9 Photomicrograph of normal synovial membrane taken from a 3 week control knee joint (hematoxylin and eosin × 38)



Figure 10 Photomicrograph of synovial membrane taken from a 3 week impacted knee joint (hematoxylin and eosin × 39) Note increased collagen



Figure 11. Photomicrograph of pericapsular area in a 6-week impacted knee joint showing foreign body giant cells (hematoxylin and eosin × 32).



Figure 12. Photomicrograph of degenerating periarticular cartilage taken from a 3-week loaded tibia. "A" denotes capsule, "B" periarticular cartilage, "C" subchondral bone (hematoxylin and eosin × 15).



Figure 13. Higher magnification of Figure 12 showing marrow and blood vessels from the subchondral bone invading the zone of calcified cartilage (hematoxylin and eosin × 32)



Figure 14 Photomicrograph of normal periarticular tibial cartilage from a 3 week control animal A denotes capsule B cartilage and C subchondral bone (hematoxylin and eosin × 15)

of blood vessels into the cartilage (Figure 13) Periarticular cartilage from the control tibia is shown in Figure 14

DISCUSSION

Previous studies

Radin and co-workers using a similar experimental model found that repetitive impact loading of rabbit knee joints resulted in subchondral bone stiffening (Radin et al 1973) They proposed that this stiffening is due to healing micro-fractures occurring consequent to repetitive impact loads It has also been suggested that cartilage degeneration is preceded by and attributable to stiffening of the subchondral bone

Their work however appears to suffer from two limitations Firstly the rabbit cartilage on which they based their conclusions was distal femoral while the subchondral bone used was proximal tibial Statements relating subchondral bone stiffness to cartilage degeneration are therefore not necessarily valid (Radin et al 1973) Secondly they have reported subchondral bone stiffening secondary to callus formation as early as the sixth day during impact loading Mechanical studies of fracture healing in rabbits have shown that the original strength of the fracture is not regained until the seventeenth day post fracture (Brighton & Krebs 1972)

Lereim et al (1974) studying patients with rheumatoid and osteoarthritis of the knee found that the hardness of the subchondral bone was significantly less in these subjects than in normal bone

Subchondral bone changes

The findings in this study indicate that repetitive impact loading through rabbit knee joints results in a progressive increase in the deformability of the subchondral bone under a constant force This is supported by the steady rise in the average deformation values of the impacted subchondral bone cores with time (Figure 6) The higher value of the modulus of elasticity in the control tibial core as opposed to the impacted core suggests that subchondral bone softening occurs with impact loading (Figure 5) The increased incidence of permanent deformation in the impacted cores (10) as opposed to the control (2) also suggests that the impacted bone was not as strong as the control

Etiology of subchondral bone changes

No definite explanation for the changes noted in the subchondral bone is proposed from this work Osteoporosis (decreased

inorganic bone matrix) secondary to hyperemia of the subchondral bone could account for the increased fragility of the impacted tibial cores (Figure 13). This is supported by the work of Harrison et al (1953) They have shown, in osteoarthritic femoral heads, that vascular proliferation and marrow invasion result in osteoporosis Seireg & Kemple (1969), however, found no change in the mineral or collagen content of rat tibiae subjected to prolonged cyclic loading

The reaction of the synovial membrane in this experimental model is thought to be non-specific, although local or metabolic factors may have been induced These could account for the changes seen

The increasing deformation of the cancellous bone may have a more complex etiology Since each loaded knee received 16,800 impacts per week, fatigue failure of individual trabeculae may be responsible Fatigue fractures have been produced experimentally in cadaveric human femoral necks with cyclic loads approximating four times body weight (Griffiths et al 1971) While not conclusive, the abnormal trabecular seen in Figure 8 is suggestive of fatigue fractures The lack of displacement coupled with the periosteal reaction resembles a fatigue fracture occurring in clinical practice Absence of cellular activity may be explained by the preparation of the specimen, since the reflected light microscopy technique has the advantage of retaining the structural integrity of cancellous bone, but distorting the cellular detail As a result, the cellular component of callus may be absent (Pugh et al 1972)

Isolated trabecular fatigue fractures of human femoral necks occurring in subchondral bone in association with osteoarthritis, rheumatoid arthritis, and subcapital fractures have been reported (Todd et al 1972)

It is unlikely that fatigue fractures can fully explain the etiology of the subchondral bone changes It should be stressed that their occurrence was rare and did not increase in frequency as the mechanical deformation increased

Etiology of articular cartilage changes

The mechanism of cartilage degeneration with impulse loading is likewise unclear. Direct pressure is known to be incompatible with cartilage survival presumably because of interference with nutrition (Salter & Field 1969) Repetitive loading may also interfere with cartilage survival by expressing a small amount of water from the matrix with each cycle This results in a gradual diminution of the viscous component of dampening thus exposing the matrix to mechanical deformation and degeneration (Freeman 1973) Fatigue of cartilage produced experimentally is not associated with mucopolysaccharide depletion (Weightman et al 1973)

Harrison et al (1953) studying osteoarthritis in human femoral heads showed that there is early invasion of cartilage by marrow and subchondral blood vessels They emphasize that this invasion first occurs in non-weightbearing areas The periarticular non-weightbearing area from a 3-week impacted tibia supports this view (Figures 12 and 13) It must be emphasized that the hyperemia seen in the subchondral bone is non-specific and may be a local reaction to trauma

Relationship of subchondral bone changes to cartilage degeneration

Increased deformability of the subchondral bone would result in decreased structural support of the overlying cartilage Articular cartilage devoid of support would be subject to collapse under loading This could produce high stress concentrations both internally and tangentially thus resulting in fatigue of cartilage

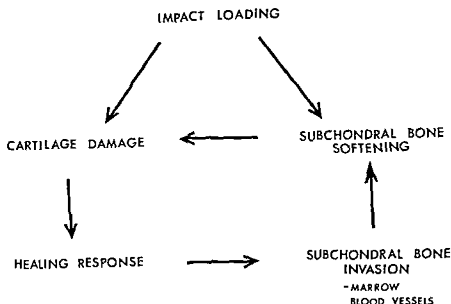


Figure 15 Diagram summarizing proposed mechanisms of experimental degenerative joint disease secondary to cyclic impact loading

The time relationship between cartilage and subchondral bone changes in experimental degenerative joint diseases is open to three theoretical pathways Following induction by impulse loading cartilage degeneration may precede, follow or occur simultaneously with subchondral bone changes

This work supports the concept that subchondral bone changes and cartilage degeneration occur concurrently in joints subjected to mechanical trauma by impact loading Cartilage and subchondral changes were not seen until the third week of testing

A summary of the proposed mechanism of experimental degenerative joint disease secondary to impact loading is shown in Figure 15

SUMMARY

1) Eighteen male mature Whiteland rabbits received repetitive impulse loads slightly larger than body weight through one knee joint for periods of 1 to 6 weeks

2) The subchondral bone cores from impacted tibiae showed progressive increased deformability under a constant force

3) Reflected light microscopy showed evidence of fatigue fractures occurring in trabecula from the impacted tibiae

4) The increased deformability of the impacted subchondral bone may be related to osteoporosis secondary to hyperemia

5) Cartilage studies from impacted tibiae suggest that degeneration occurs concurrently with alterations in the mechanical properties of the subchondral bone

6) Cartilage degeneration occurred first and with greater severity in nonweightbearing areas of the articular cartilage

7) This mechanical model supports the view that cartilage degeneration may be affected by

(i) the direct effect of repetitive mechanical compression, i e fatigue

inorganic bone matrix) secondary to hyperemia of the subchondral bone could account for the increased fragility of the impacted tibial cores (Figure 13). This is supported by the work of Harrison et al (1953). They have shown, in osteoarthritic femoral heads, that vascular proliferation and marrow invasion result in osteoporosis. Seireg & Kemple (1969), however, found no change in the mineral or collagen content of rat tibiae subjected to prolonged cyclic loading.

The reaction of the synovial membrane in this experimental model is thought to be non-specific, although local or metabolic factors may have been induced. These could account for the changes seen.

The increasing deformation of the cancellous bone may have a more complex etiology. Since each loaded knee received 16,800 impacts per week, fatigue failure of individual trabeculae may be responsible. Fatigue fractures have been produced experimentally in cadaveric human femoral necks with cyclic loads approximating four times body weight (Griffiths et al 1971). While not conclusive, the abnormal trabecular seen in Figure 8 is suggestive of fatigue fractures. The lack of displacement coupled with the periosteal reaction resembles a fatigue fracture occurring in clinical practice. Absence of cellular activity may be explained by the preparation of the specimen, since the reflected light microscopy technique has the advantage of retaining the structural integrity of cancellous bone, but distorting the cellular detail. As a result, the cellular component of callus may be absent (Pugh et al 1972).

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THE EFFECT OF OSTEOTOMY AND CARTILAGE DAMAGE ON MITOTIC ACTIVITY

An Experimental Study in Rabbits

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Malmö Sweden

In 15 rabbits osteotomy and osteotomy including cartilage damage were performed With autoradiography (^{3}H thymidine) it was shown that only one knee in the osteotomy group had labeled chondrocytes in the tibial cartilage In the knees with articular damage labeled chondrocytes were found in the femur as well which could be the result of a factor liberated from the damaged cartilage, a factor stimulating mitotic activity

Key words cartilage mitosis of chondrocytes autoradiography, chalones

Accepted 27 i 77

Mitotic division of chondrocytes has never been demonstrated with any certainty in normal adult joint cartilage from animals or human beings When a well defined zone with calcified cartilage has been formed basally in articular cartilage and when tidemark has developed the chondrocytes cease to divide Mankin 1968 1970 Hulth et al 1972 Telhag 1972) Previous investigations have shown that local traumatization of articular cartilage gives rise to local repair The chondrocytes around the defect recover their ability to take up ^{3}H-thymidine i e to divide (De Palma et al 1966) Havdrup et al (1976) have shown that when the patella is scored chondrocytes in the femur and the tibia can also take up tritiated thymidine In the same investigation they found that after arthrotomy of the rabbit's knee without cartilage damage some chondrocytes were labeled with tritiated thymidine

The aim of the present investigation was to determine the effect of osteotomy of the tibia and cartilage damage without arthrotomy and compare this with pure osteotomy of the tibia

MATERIAL AND METHODS

Fifteen full grown rabbits were used (gray Silver) The animals were divided into three groups All the animals were operated upon under intravenous Nembutal anesthesia (Abbott) under sterile conditions *In group I* a medial incision was made in the right knee over the medial tibial condyle and from there an osteotomy of the tibia was made about ½ cm from the proximal end of the tibia by sawing the condyle halfway to the lateral side (*Figure 1*) The left knee joint served as a control In

Financial support was obtained from Svenska Läkaresällskapet Herman Järnhardts Stiftelse and Riksforl undet mot Reumatism

(ii) the decrease in mechanical support of the subchondral bone

ACKNOWLEDGMENTS

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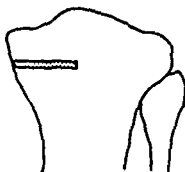


Figure 1 Osteotomy in the right knee

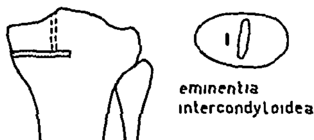


Figure 2 Osteotomy and cartilage damage in the left knee

group 2 the same procedure was carried out as in group 1 in the left knee but after making the osteotomy the articular cartilage was damaged for a length of 2 mm through the osteotomy line with a dentist's drill Precautions were taken not to damage the femoral condyle (Figure 2) At no time was the synovial membrane cut The right knee served as a control In group 3 the right knee was operated upon as in group 1 and the left as in group 2

Fourteen days after the operation the animals were killed by an i v overdose of Nembutal Six hours before sacrifice 40 μCi ^{3}H thymidine was injected into each knee joint X rays were then taken to identify the osteotomy and to find out whether the epiphyseal line was closed Both knee joints were removed and fixed in 10 per cent formalin The tibia and the femur were dissected free and treated separately With a circular saw the tibia and the femur were divided into two halves in the frontal plane These halves were then decalcified in 40 per cent formic acid The specimens were embedded in paraffin and cut into sections (4 7 μ) The sections were stained with hematoxylin eosin according to van Gieson and with toluidine blue Autoradiograms of routine histological specimens from both knees were prepared according to the dipping method with Ilford K2 liquid emulsion After exposure of the specimens for 3 weeks the autoradiograms were developed in Gevaert X ray developer G 230 and fixed in Gevaert X ray fixer G 305 The preparations were stained through the emulsion with May hematoxylin

RESULTS

Histological examination of specime from two animals in group 3 reveal small signs of the epiphyseal line but t animals had a well defined layer of c cified cartilage and a 'tidemark' cou be found

In group 1, where osteotomy was pe formed in the right knee, two label chondrocytes were found in one knee the tibia However, no labeled chondr cytes could be found in the other rig knee joints or in the left unoperated kne The articular cartilage showed no sig of degeneration, such as death of th chondrocytes, flaking or fibrillation N clusters were seen At the margins pr liferation of cells in and near the per osteum could be seen and in additio osteoblastic activity with new bone fo *mation*

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Histologically a few clusters were found around the damaged cartilage Around the defect there was fibrillation of the cartilage as well as necrosis of the chondrocytes close to the injury The defect was filled with fibrous tissue No labeled chondrocytes were found in the vicinity of the cartilage defect

DISCUSSION

Previous investigators have shown that the ability of the chondrocytes to take up ³H thymidine i e to divide decreases with advancing age and when a well defined zone with calcified cartilage can be found and when tidemark' has developed the chondrocytes cease to divide (Mankin 1968) Such tidemarks were found in all the joint cartilages in the present investigation, although res idues of the epiphyseal line were found in t ...

... c u ular defect in the femoral head in rabbits They could not find any degen erative cartilage changes outside the de fect after 20 weeks However, after 40 52 weeks degeneration of the cartilage was seen

Reimann (1973) performed osteot ... com ... co ... ki ... ex ... s ... to degenerative carti lage changes but no signs of osteophytes

In this investigation the articular car tilage did not reveal any changes after 2 weeks except for local changes around the cartilage injury This is in agreement with the findings of Wigren & Olerud (1973) who removed a part of the medial femoral condyle and fixed it back with a metal screw

Havdrup et al (1975) have shown that arthrotomy after scoring of the patella gave mitotic activity not only in the patella but also in the tibia and the femur in the same knee suggesting that a factor stimulating mitotic activity had been released In the articular cartilage of the contralateral knee where only arthrotomy was performed some chon drocytes were labeled with ³H thymidine

In an earlier investigation, Telhag (1973) could not find any mitotic activity after arthrotomy alone In this study we found sparse labeled chondrocytes also in the femur, which supports the theory that when the cartilage is damaged, a factor is liberated, which stimulates mitotic activity This factor might be a proteo lytic enzyme from the injured cartilage, a factor that has a chalone effect, i e, an effect resulting in reducing the concen tration of the cell specific inhibitors of the mitotic activity in normal adult joint cartilage

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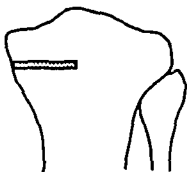


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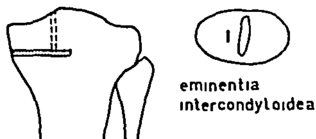


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over a wide dose range (Langeland 1975 b) The lowest doses being found effective were probably just above the physiologic This makes it reasonable to study more thoroughly the *in vitro* effect of oestradiol in concentrations near to the physiologic

MATERIAL AND METHODS

Young mature female rats of the Wistar/Mollegaard strain were used in experiments 1 and 3 In experiment 2 a Sprague Dawley strain of the same weight range was used The animals were given the usual laboratory rat diet and water *ad libitum* All rats were oophorectomized 1 week before being killed by a blow to the neck and decapitation At oophorectomy the body weights ranged from 183 g to 210 g and at sacrifice from 206 g to 235 g The experiments were designed for paired comparisons and accordingly all handling treatment incubations and analyses were run simultaneously for all samples to be compared as pairs For one incubation series two animals were killed The metaphyseal bones from the upper tibiae and the lower femurs of both sides were removed and handled as described previously (Langeland 1975 a b) All the bone pieces were pooled and thereafter divided into four portions of approximately equal weight.

Incubations and analyses were as described in detail elsewhere (Borle & Nichols 1960 Flanagan & Nichols 1969 Langeland 1975 a, b) Also the incubation medium was as described previously (Langeland 1975 b) except for the addition of different doses of oestradiol 17 β (SIGMA) solubilized in alcohol and parathyroid hormone (Para Thor Mone Lilly) as follows

Exp 1/Medium 1 (control)	5 ‰ C_2H_5OH
Exp 1/Medium 2	
oestradiol 10^{-9} M	5 ‰ C_2H_5OH
Exp 1/Medium 3	
oestradiol 10^{-8} M	5 ‰ C_2H_5OH
Exp 1/Medium 4	
oestradiol 10^{-7} M	5 ‰ C_2H_5OH
Exp 2/Medium 1 (control)	5 ‰ C_2H_5OH
Exp 2/Medium 2	
oestradiol 3×10^{-5} M	5 ‰ C_2H_5OH
Exp 3/Medium 1 (control)	5 ‰ C_2H_5OH
Exp 3/Medium 2	
parathyroid hormone (PTH) (Para Thor Mone Lilly) 1 USP unit per ml	+ 5 ‰ C_2H_5OH
Exp 3/Medium 3	
PTH 1 USP unit/ml + oestradiol 17 β 10^{-9} M	+ 5 ‰ C_2H_5OH
Exp 3/Medium 4	
PTH 1 USP unit/ml + oestradiol 17 β 3×10^{-5}	+ 5 ‰ C_2H_5OH

Statistics Wilcoxon s test for paired samples was applied to test for statistically significant differences (Wilcoxon 1945 1947) The differences were considered significant when $2\alpha < 0.05$

RESULTS

Most of the results from experiment 1 are summarized in Table 1 and Figure 1 The means and standard deviations are given However, because these experiments were designed for paired comparison the standard deviations cannot be used for estimating significant differences Among other things, weight and age of animals differed somewhat from one paired group to another This may influence the standard deviations, but not the evaluation of the results when studied as paired samples

Studying Table 1, it will be observed that the incorporation rates of the bone pieces treated with oestradiol 17 β 10^{-9}, 10^{-8} or 10^{-7} M were not significantly different from controls

In Table 2 are presented the synthesis and incorporation patterns of the bone pieces incubated with oestradiol-17-β 3×10^{-5} M The synthesis rate was significantly reduced with this high oestradiol concentration in the medium while the *percentage of synthesized collagen* incorporated into the bone was unchanged, as was the percentage of total collagen in incubated bone that was passively solubilized in the incubation medium

As can be seen from Table 1 and Figure 2 there was a greater variance in the results when studying the resorption than when looking at the incorporation

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THE *IN VITRO* EFFECT OF OESTRADIOL ON COLLAGEN METABOLISM IN METAPHYSEAL RAT BONE

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Surviving bone pieces from the femoral and tibial metaphyses of young castrated female rats have been incubated for 6 hours with concentrations of oestradiol-17 β ranging from 10^{-9} M to 3×10^{-5} M and the *in vitro* collagen metabolism studied The addition of oestradiol did not produce any change in the resorption patterns of bone collagen expressed as release of hydroxyproline to the medium Parathyroid hormone in the incubation medium increased the resorption and decreased the incorporation rate insignificantly Addition of both parathyroid hormone and oestradiol to the incubation medium produced a significant increase in resorption and a decrease in incorporation rate as compared with the control incubations The bone pieces incubated with *oestradiol 17 β* 3×10^{-5} synthesized and incorporated significantly less hydroxyproline than the control bone pieces This is, however, a very high concentration of the hormone and the physiological significance of the observation is doubtful

Key words bone resorption, bone regeneration, collagen, oestradiol parathyroid hormone

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The *in vitro* effects of oestrogens upon bone have been studied in a few works during the last decade (Stern 1969, Atkins et al 1972, Nordin et al 1970) All these studies have been based on some kind of tissue culture technique They have been mostly concerned with the resorption of bone minerals, and very high concentrations of oestrogens have as a rule produced a reduced resorption rate or an inhibition of the parathyroid induced bone resorption

The tissue culture techniques are, however, limited to studies of foetal or neonatal bone Great progress would therefore be made if any similar effects were demonstrable in mature bone incubated *in vitro*

In target tissues oestrogens have been found to induce the synthesis of a specific protein *in vitro* (Katzenellenbogen & Gorski 1972, Means & O Malley 1971 1972) In contrast to the reduced resorption rate of the tissue culture of bone this specific protein was synthesized at what is believed to be physiologic doses of oestrogens (Exley 1969, Brown Grant et al 1970) Administered *in vivo* oestradiol has been shown to be effective in reducing bone collagen resorption in vitro

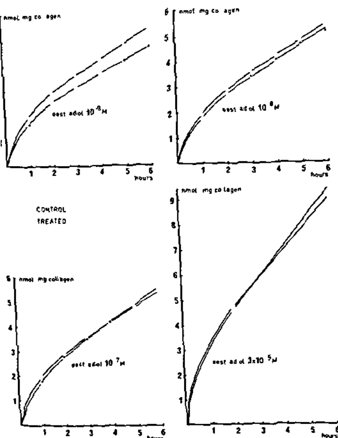


Figure 1 Total cumulative release of hydroxyproline to the medium during the 6 hours of incubation with different doses of oestradiol in the medium Each point represents the mean of 3 to 7 samples The standard deviations have been omitted since they overlapped each other In each part of the figure the mean of one treated series and the corresponding untreated control series (experiments 1 and 2) are given None of the differences between treated and corresponding control incubations were significant

two strains of rats used in the present study should be noted

DISCUSSION

Stimulating effects on protein synthesis of oestrogens added *in vitro* have been reported only in studies of target tissues (Katzenellenbogen & Gorski 1972, Means & O'Malley 1971, 1972) Studies on bone from mammals other than mice (Vaes & Nichols 1962, Atkins et al 1972, Stern 1969 Nordin et al 1970) have never revealed any stimulating effect of oestrogens on bone collagen synthesis *in vitro* However, as pointed out in the introduction most of these studies have been undertaken with hormone concentrations far from what is believed to be "physiologic" According to Exley (1969) the physiologic non-oestrus level of oestradiol-17-β in peripheral rat plasma is 1–2 ng per 100 ml plasma ($\approx 1\text{–}2 \times 10^{-10}$ M) It is not obvious that a similar concentration added *in vitro* is comparable However, the doses most effective in stimulating protein synthesis in uterine tissue in the work of Katzenellenbogen & Gorski (1972) were 10^{-9} to 10^{-8} M, in other words concentrations near to the physiologic

Based on these facts the present study was first planned with concentrations of 10^{-9} to 10^{-7} M of oestradiol-17-β Although a slightly higher mean incorporation rate of the oestradiol 10^{-9} M group (Figure 1) can be seen, the treated bone did not behave significantly differently from control bone in any of the examined param-

Table 1 Collagen metabolism in rat metaphyseal bone treated in vitro with different doses of oestradiol-17-β (experiment 1). Incorporation and resorption are given in nanomols per mg incubated collagen per hour incubation. In this table the net resorption and incorporation are given (cf. text and Figure 1). "Solubility per cent" is the percentage of the collagen in incubated bone passively solubilized in the medium. S.D. = Standard deviation

Treatment	n	Incorporation Mean ± S.D.	Resorption Mean ± S.D.	Solubility Mean ± S.D.
Control	7	0.49 ± 0.05	0.41 ± 0.17	0.152 ± 0.056
Oestradiol 10^{-9} M	7	0.57 ± 0.05	0.29 ± 0.11	0.150 ± 0.061
Oestradiol 10^{-8} M	7	0.46 ± 0.05	0.40 ± 0.19	0.152 ± 0.060
Oestradiol 10^{-7} M	7	0.54 ± 0.14	0.39 ± 0.25	0.159 ± 0.068

1 a-d, that there was no significant difference in the total release of hydroxyproline to the medium during the total incubation period, and accordingly no difference in the amount of collagen passively solubilized in the medium (Tables 1 and 2 – "Solubility"). The total hydroxyproline found in the medium derives from three different sources: 1. Active cell mediated collagen resorption. 2. Passive collagen/hydroxyproline solubilization in the medium. 3. Newly synthesized hydroxyproline not incorporated into the bone pieces (Flanagan & Nichols 1969).

The results of the present study concerning the possible "interaction" between oestradiol and PTH are summarized in Table 3 and Figure 3. As will be seen, there was an insignificant difference between control and parathyroid hormone treated bone in collagen synthesis rates. Adding oestradiol-17-β to the medium in addition to PTH reduced incorporation rates to values significantly below the results of the controls. However, none of the oestradiol PTH treated groups present synthesis or incorporation rates significantly different from those treated with PTH alone.

There was no difference in the percentage of synthesized hydroxyproline incorporated into the bone pieces (Table 3).

The addition of PTH to the incubation medium (Figure 3) increased the resorption rate insignificantly ($0.05 < 2\alpha < 0.10$). When oestradiol-17-β 10^{-9} M or 3×10^{-5} M was added as well, the resorption rates significantly increased compared with untreated control incubations, while there was no significant difference compared with the bone pieces treated with parathyroid hormone alone (Figure 3).

The percentage of collagen passively solubilized in the medium during the first 2–3 hours of incubation remained unaffected by the treatment given.

The different metabolic pattern of the

Table 2 Collagen metabolism in rat metaphyseal bone treated in vitro with oestradiol 17-β 3×10^{-5} M. Values of synthesis are given in nanomol hydroxyproline per hour per mg incubated collagen

Treatment	n	Synthesis Mean ± S.D.	Per cent incorporated Mean ± S.D.	Solubility percentage Mean ± S.D.
Control	6	1.26 ± 0.10	78.4 ± 5.5	0.224 ± 0.048
Oestradiol 3×10^{-5} M	6	1.09* ± 0.16	78.5 ± 8.1	0.250 ± 0.075

* Significantly different from control ($P < 0.05$)

This difference may possibly be caused by the longer incubation time possible with tissue culture techniques and by the addition of serum to the incubation medium in the cited studies (Stern & Raisz 1966 1967) Moreover, based on the theory that oestrogens inhibit the bone resorptive activity of parathyroid hormone (Burkhardt & Jowsey 1967, Jowsey & Raisz 1968 Nordin et al 1970), the studies of Stern (1969), Atkins et al (1970) have been concerned with the effect of oestrogens on parathyroid induced bone resorptions This oestrogen/parathyroid hormone counteraction theory has been considered in experiment 3 of the present study However, oestradiol 17 β in the tested concentrations had virtually no antiresorptive effect upon the bone treated with PTH Since the techniques applied in the present study are very different from the cited tissue culture studies (Stern 1969 Atkins 1972) they are not directly comparable

However the concentrations found effective in reducing bone resorption *in vitro* are very high—10 000 to 100 000 times higher than what is believed to be physiologic This does not correspond well to the results obtained with the hormone administered *in vitro* as reported previously (Langeland 1975 b), where doses probably near to the physiologic were found effective in inhibiting resorption of bone collagen

As pointed out by Stern (1969) several steroids inhibit bone resorption (and bone synthesis?) when added *in vitro* at these high concentrations She doubts that the effects of steroids at these concentrations are related to their hormonal activity At least it seems questionable whether the effects found at these high concentrations are comparable with the effects found after *in vivo* administration of the hormone

In conclusion it may be pointed out that in the present study oestradiol added *in vitro* in physiologic amounts had no effect on bone metabolism, and it had no antiresorptive effect on PTH treated bone In a previous study (Langeland & Teig 1975) it was found that oestradiol administered *in vivo* had the same antiresorptive effect on bone in thyroparathyroidectomized rats as it had in animals with intact thyroparathyroid glands All these findings suggest that the effect of oestradiol on bone is independent of PTH However, since these effects are not demonstrable when the hormone is administered *in vitro* the possibility that it may act indirectly, e g, via the hypophysis or some other mediator, should be investigated further

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Table 3 Collagen metabolism in rat metaphyseal bone treated in vitro with parathyroid hormone and oestradiol 17-β The total collagen synthesis, percentage of synthesized collagen incorporated into incubated bone pieces and percentage of incubated bone collagen passively solubilized in the medium are given Values in nmol per mg collagen per hour of incubation or in percentages

Treatment	n	Synthesis Mean ± S D	Per cent incorporated Mean ± S D	Solubility percentage Mean ± S D
Control	6	1 05 ± 0 17	70 4 ± 3 8	0 20 ± 0 03
Parath hormone	7	0 99 ± 0 14	71 6 ± 4 2	0 22 ± 0 04
Parath + oestradiol 10 9	6	0 93* ± 0 13	71 1 ± 4 3	0 31 ± 0 09
Parath + oestradiol 3 × 10 5	7	0 89* ± 0 18	69 0 ± 2 4	0 25 ± 0 08

* Significantly different from control ($P = 0\ 02$)

eters Raising the oestradiol concentration to 3×10^{-5} M reduced the collagen synthesis rate significantly, and produced an insignificant reduction in the resorption rate This is a concentration of oestradiol-17-β comparable with the concentrations Kuchler & Grauer (1962) found to inhibit growth of L-strain fibroblasts Atkins et al (1972) found oestradiol to inhibit the resorptive action of parathyroid hormone at a concentration near to 10^{-4} M, and at 10^{-5} Stern (1969) found a similar effect These experiments were performed in tissue culture

The results obtained in the present study do not reveal any effect of oestradiol-17-β, added *in vitro*, upon bone resorption The works of Stern (1969) and Atkins et al (1972) revealed a clear-cut reduction in PTH-induced bone resorption at high concentrations of oestradiol

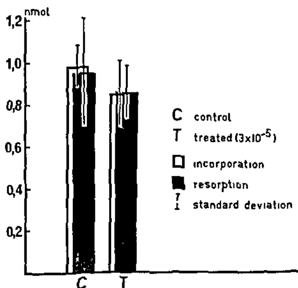


Figure 2 In vitro treatment of metaphyseal bone from castrated female Sprague Dawley rats The mean incorporation and resorption rates of bone pieces treated with oestradiol-17 β 3×10^{-5} M and their paired untreated controls are given Each column represents the mean and standard deviation of 6 incubations The treated group (T) synthesized significantly less hydroxyproline than the control incubations ($2\alpha = 0\ 05$)

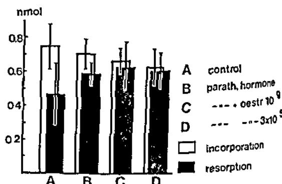


Figure 3 In vitro metabolism of metaphyseal rat bone treated with parathyroid hormone alone and in combination with oestradiol 17 β 10^{-9} M or 3×10^{-5} M Values are in nanomol per mg incubated bone collagen per hour of incubation The incorporation rates of group C and D are significantly reduced compared with group A and the resorption rates of the same groups are significantly increased as compared to group A ($2\alpha = 0\ 05$)

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THE SPINAL ABNORMALITIES IN THALIDOMIDE EMBRYOPATHY

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In 1968 a study was made of the spinal changes in 32 children with multiple congenital abnormalities due to thalidomide Twenty-eight of these children have been traced and their spinal changes reviewed Only four patients had normal spines on radiography In eight children scoliosis was present and had progressed though it was still of mild degree Disc and end plate abnormalities were seen in 14 children and in some appeared to be progressive leading to intervertebral fusion

Key words thalidomide congenital defects scoliosis spinal deformity

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The limb defects of children affected by thalidomide and the problems associated with their management have been the subject of considerable attention in the orthopaedic and prosthetic literature However almost any system of the body may be involved in the syndrome of thalidomide embryopathy (Smithells 1973) Marquardt first drew attention to changes in the vertebral column in this syndrome in 1967 A radiological study of the spines of 64 children with thalidomide induced deformities was made by Andrian Werburg (1966) Thirty nine had scoliosis and 16 had a dorsolumbar kyphosis Similar changes have been reported in the German literature by Petersen 1967) Jager et al (1967) and Ruffing 1974)

The spinal abnormalities of 32 children who were then between 4 and 8 years of age were reported by Nichols et al in 1968 These children are now between 10 and 14 years of age at the start of their adolescent growth spurt which is an appropriate time to review the extent of their spinal deformities

MATERIAL

Limb defects

All 32 children have upper limb defects one child has one *normal* arm Nineteen children have normal lower limbs three have normal lower limb bones with one or both hip joints dislocated and one has proximal focal femoral deficiency but otherwise normal legs

Previous spinal changes

The spinal abnormalities were previously classified as follows

		Children
1	Local anomalies of bone development	
	a) Spina bifida	3
	b) Fusion of adjacent spinous processes	2
2	Scoliosis	18
3	Wedge deformity of solitary vertebral bodies	4
4	Calcification in intervertebral spaces seen in the form of horizontal flakes	3

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Figure [illegible] Same subject aged 11 years 11 months [illegible] vertebral fusion T11 to T1[illegible] and L1 to L[illegible]

with associated symptoms and functional restriction might occur relatively early in life and the need for continuing observation and for wider study of similar children was emphasized

In the current review two main types of spinal abnormality were noted scoliosis and disc changes The presence of even a mild scoliosis at the start of the adolescent growth spurt is a cause for concern The degree of scoliosis present though minor in most cases was nevertheless measurable and in eight children became significantly worse The curves were all long and paralytic in type In this small series there did not appear to be a correlation between the presence of scoliosis and limb asymmetry Four children with thoracic curves had asymmetrical upper limbs whereas ten children with thoraco-lumbar curves and two with lumbar curves all had symmetrical indeed normal lower limbs

Changes in the discs and end plates were found in 12 of the 32 children in the initial study they were present in fourteen of the 28 children in the current review and in eight of these intervertebral fusion had occurred The only other spinal condition in which fusion such as this takes place is ankylosing spondylitis but there was no evidence that these children were suffering from this disease It was thought at first that decreasing lumbar lordosis might result from the presence of fusion of the anterior parts of the vertebral bodies with cessation of growth at this site and continuing growth of the posterior elements In only three of the 14 children in whom repeated measurements have been made has the lumbar curvature decreased and it does not appear to be related to the type of limb deformity which is present or to foot usage The point we wish to emphasize is that in some children disc and end plate abnormalities which may lead to vertebral fusion do seem to be extending to other levels in the spine The implications of this in these children who depend so much on supple spinal movements to use their deficient limbs to best advantage are obvious Further studies are in progress and careful follow up is essential

ACKNOWLEDGEMENTS

We are indebted to our orthopaedic colleagues at the Nuffield Orthopaedic Centre and elsewhere for permission to study the children in their care and for arranging for radiographs to be taken

5 End-plate and disc deformities
 (a) Disc space narrowing alone 2
 (b) Deformities of discs and end-plates resulting in abnormal vertebral body shape, one vertebra overgrowing to compensate for a defect in an adjacent vertebra, usually of the anterior surfaces 9
 (c) Disc narrowing and deformity leading to partial or complete fusion of adjacent vertebral bodies 5

Present review

Recent radiographs of the spines of 28 of the children were obtained The changes between the original study and the current review were as follows

Local anomalies of bone development Defects of the neural arch were more obvious in the follow-up series In seven children minor changes such as asymmetry between the size of ribs transverse processes or pedicles, were apparent on the follow-up films but not on the earlier ones

Scoliosis In all, 20 children had scoliosis of varying degrees In eight children the scoliosis had become worse In two, the scoliosis was of mild degree originally, and later reversed In two, no scoliosis was apparent on review Two children developed scoliosis which was not noted originally In most of the children the scoliosis measured less than 15° and was of the long paralytic type In one child the curve measured 25° One child in the earlier series had a severe scoliosis but in addition to being exposed to thalidomide he had multiple epiphyseal dysplasia and he died before review

Wedge deformity In four cases additional deformities of the vertebrae were noted

Disc space calcification In two additional children disc space calcification had appeared In one this was seen at only two levels but in the other it was extensive

Disc and end plate abnormalities In the earlier study this type of change was present in 12 patients it had appeared in two or more in the current review In two children frank intervertebral fusion which had not been noted before had occurred In two others intervertebral fusion had extended to other levels in the spine as seen in Figures 1 and 2 Reduction of the lumbar lordosis was noted in 10 children Only two of the latter had normal legs

DISCUSSION

In the earlier study of this group of 32 children with multiple congenital limb deformities, believed to be due to thalidomide, only eight (25 per cent) had no radiological abnormality of the spine Mild scoliosis was noted in 17 patients Twelve patients had abnormalities of the end-plates and intervertebral discs ranging from narrowing of the disc space to severe deformities of the end plates and anterior fusion of the vertebral bodies It was first thought that the changes might be secondary to frequent hyper flexion associated with using the feet for dressing, feeding and playing, but abnormalities were found in children with severely deformed lower limbs who were unable to use their feet in this way Though there was no evidence of progression of abnormalities in the spine, it was thought that secondary degenerative changes



Figure 1 Lumbar spine of child aged 4 years 2 months, showing deformities of the discs and end plates from T 9 to S 1 and partial anterior fusion of L 3 and L 4 vertebral bodies



Figure 2 Same subject aged 11 years 11 months Intervertebral fusion T 11 to T 12 and L 1 to L 4

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THE CHANGED PATTERN OF BONE AND JOINT TUBERCULOSIS IN NORWAY

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The reduced incidence of bone and joint tuberculosis in Western countries and the change in the age groups afflicted are well known facts In addition, there are other less conspicuous changes multiple lesions and involvement of the spine and sacro iliac joints are rarer than before while trochanteric involvement is becoming more frequent In spinal cases the lesion is now more often localized to the dorsal region All these changes may be due to the change in age distribution of the patients

Key words spinal tuberculosis changed pattern bone and joint tuberculosis clinical picture pattern

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It is a well known fact that tuberculosis of bone and joint has practically disappeared in many Western countries, e g, Norway It therefore seems appropriate to report on the present day status of the disease as well as to make a comparison with the situation some decades ago

The incidence of new cases of tuberculosis of all types in Norway has declined during the period 1946 to 1975 by 90 per cent From 308 4 per 100 000 population to 11 9 By law, all new cases of tuberculosis in the country should be notified to the health authorities For various reasons the notification during the war was not reliable and therefore only post war numbers are used

The incidence of bone and joint tuberculosis has also declined Five-year numbers are used in order to get numbers of a reasonable size In the period 1946 50, a total of 26 4 new cases were notified per 100,000 population, in 1971-75 the number was 2 6, i e, a drop of 90 per cent The decline has been greatest in the younger age groups, with an average of 96 per cent for those below 50 years and 63 per cent for older people (Table 1)

The clinical picture in patients with bone and joint tuberculosis has changed To study this change, records of two groups of patients were reviewed One group consisted of the first 100 patients admitted to Martina Hansens Hospital, following its inauguration in 1936, and the second group consisted of the last 100 patients admitted up to the end of 1975 It needed less than 1 year to collect the first group, and approx 6 years (1970-75) to collect the second This gives an indication of the reduced incidence of the disease Moreover, in 1936, the hospital was only one of seven hospitals for bone and joint tuberculous patients, while to-

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THE CHANGED PATTERN OF BONE AND JOINT TUBERCULOSIS IN NORWAY

BERNHARD PAUS

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The reduced incidence of bone and joint tuberculosis in Western countries and the change in the age groups afflicted are well known facts In addition there are other less conspicuous changes multiple lesions and involvement of the spine and sacro iliac joints are rarer than before while trochanteric involvement is becoming more frequent In spinal cases the lesion is now more often localized to the dorsal region All these changes may be due to the change in age distribution of the patients

Key words spinal tuberculosis changed pattern bone and joint tuberculosis clinical picture pattern

Accepted 25 ii 77

It is a well known fact that tuberculosis of bone and joint has practically disappeared in many Western countries, e g, Norway It therefore seems appropriate to report on the present day status of the disease as well as to make a comparison with the situation some decades ago

The incidence of new cases of tuberculosis of all types in Norway has declined during the period 1946 to 1975 by 90 per cent from 308 4 per 100 000 population to 11 9 By law all new cases of tuberculosis in the country should be notified to the health authorities For various reasons the notification during the war was not reliable and therefore only post war numbers are used

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The clinical picture in patients with bone and joint tuberculosis has changed To study this change, records of two groups of patients were reviewed One group consisted of the first 100 patients admitted to Martina Hansens Hospital following its inauguration in 1936 and the second group consisted of the last 100 patients admitted up to the end of 1975 It needed less than 1 year to collect the first group, and approx 6 years (1970 75) to collect the second This gives an indication of the reduced incidence of the disease Moreover, in 1936 the hospital was only one of seven hospitals for bone and joint tuberculous patients, while to-

day all patients with this ailment are supposed to be referred to this hospital

Table 1 Notified cases of bone and joint tuberculosis per 100 000 population in Norway (cf 1946–50 and 1971–75)

Age	Notified cases/100,000 1946–50	Notified cases/100,000 1971–75	Reduction in per cent
0–14 years	14 2	0 4	96
15–29 years	43 8	0 3	
30–49 years	26 2	2 5	
50–59 years	19 3	5 2	63
60– years	12 7	6 7	

The age distribution of the patients has changed In the 1936 group, 35 patients were below 20 years of age and in 1970–75 there were two In the 1936 group, one patient was more than 50 years old, in the 1970–75 group there were a total of 80 (Table 2)

Table 2 Age of patients with bone and joint tuberculosis admitted to Martina Hansens Hospital (cf 1936 and 1970 75)

Age (years)	1936	1970–75
0–9	19	2
10–19	16	–
0–19	35	2
20–34	49	4
35–49	15	14
50–64	1	49
65	–	31
	100	100

There have also been other, less conspicuous changes in patients with bone and joint tuberculosis Localization of the lesion to the spine or sacro-iliac joints, as well as multiplicity of bone and joint lesions, has become less frequent These reductions are statistically significant A registered increase in hip joint involvement is, however, not significant (Table 3)

A review was also made of the records of the first 100 patients treated at the hospital for tuberculosis of the spine and discharged in 1936–38 and the last 100 discharged at the end of 1975 It was necessary to go back 12 years to 1963 to collect this number of patients In this latter group, 32 patients were treated for a recurrence of tuberculosis in the same vertebrae 6 to 36 years after onset

Table 3 Localization of lesions in patients with bone and joint tuberculosis admitted to Martina Hansens Hospital (cf 1936 and 1970 75)

	1936	1970–75
Spinal lesions*	55	24
Sacro-iliac joint lesions	14	–
Trochanteric lesions	1	18
Hip joint lesions	15	23
Other lesions	28	36
Total lesions	113	101
Multiplicity	17 patients	1 pat

* Patients with multiple lesions in the spine are listed once only

Multiplicity of spinal lesions has declined from 100 lesions in the first group to 101 in the more recent group The number of affected vertebrae is the same 303 and 299 Involvement of the dorsal region was more frequent in the recent group, the increase being probably statistically significant This was observed to an equal extent in recurring and new cases (Table 4)

Table 4 Localization of spinal involvement in patients admitted to Martina Hansens Hospital for tuberculosis of the spine (cf 1936–38 and 1963 75)

	1936 38	1963 75
Cervical region	4	2
Dorsal region	42	59
Lumbar region	63	40

Cases with dorsolumbar lesions are listed as dorsal if the lumbar lesion was not dominant

Table 5. Localization of lesions in patients with bone and joint tuberculosis in different age groups

Age	No of patients	Localization to the Spine	Localization to the S I Joint*	Multiplicity of lesions
0–34 years	90	57 (63 %)	12	14
35–49 years	29	12 (41 %)	2	4
50–64 years	50	13 (26 %)	–	–
65– years	31	4 (13 %)	–	–

* All sacro-iliac lesions were bacteriologically and/or histologically verified as tuberculous and do not represent misdiagnosed cases of ankylosing spondylitis Bechterew.

DISCUSSION

The reduced incidence of bone and joint tuberculosis from 1946 to 1975 corresponds with the reduced incidence of tuberculosis in general over this period. The reasons for this reduction will not be discussed here.

The change in age distribution of patients with bone and joint tuberculosis from 1936 to 1970–75 is explained by the different reductions in incidence of notified new cases in the population in the various age groups. Theoretically also a change in the population should be considered, but this possibility must be discarded as this change is minimal. The age group 0–19 years in the population declined from 34.6 *to 31.7 per cent, but* the number of patients has changed from 35 to two. The age *group 50 years or* more in the population increased from 8.4 to 11.1 per cent, but the number of patients *from one to 80*.

The reduced involvement of the *spine* and sacro-iliac joints, as well as the reduced multiplicity of bone *and joint* lesions may be due to the change in the patients' age distribution. If both groups are combined, thus increasing the numbers, it is observed that the incidence declines with increasing age (Table 5).

Table 6. Dorsal localization in tuberculosis of the spine in different age groups

Age	No of patients	Dorsal involvement
0–19 years	35	10 (30 %)
20–34 years	61	28 (45 %)
35–49 years	48	27 (56 %)
50–64 years	45	30 (67 %)
65– years	13	6 (46 %)

The increased localization in the dorsal region in cases of tuberculosis of the spine is only probably statistically significant. The increase may perhaps be due to the change to a predominance of older patients, as dorsal localization seems to become more common with increasing age. If both groups are combined the figures are as shown in Table 6.

The small number of only 13 patients 65 years old or more makes the decreased percentage in this group less *convincing*.

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RUPTURE OF THE DISTAL BICEPS TENDON

Report of Five Cases

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Five cases of rupture of the distal biceps tendon are described Three were operated on—two in the acute stage and one after 3 months—and the other two were managed conservatively The literature on this condition is reviewed and alternative forms of treatment are discussed

Key words tendon rupture, biceps injury, muscle-tendon injury

Accepted 1 iii 77

Rupture of the distal biceps tendon is relatively uncommon Various surgical methods have been described but the literature is rather sparse, particularly regarding inveterate cases It therefore seems appropriate to present and discuss five cases that were treated at this Department in the period 1969 76

CASE REPORTS

Case 1 A 58 year old man was treated conservatively for rupture of the distal tendon of the left biceps

At follow up 9 years after the injury he reported lack of strength at the elbow Examination indicated that the greater part of the biceps muscle had atrophied with considerable loss of gross muscle power in the elbow joint

Case 2 A 55 year old man was treated conservatively for rupture of the distal tendon of the right biceps

At follow up 4 years after the injury he reported very troublesome periodical pain located in the front of the right elbow joint and also in the right shoulder joint Examination indicated no appreciable loss of gross muscle power in either the upper arm or the elbow, neither was supination at the elbow impaired

Case 3 A 47 year old man experienced sudden pain in the left upper arm whilst lifting a heavy object The diagnosis ruptured distal biceps tendon was made 3 months later, at which time the gross muscle power for flexion and supination in the elbow joint was found to be impaired In view of the patient's great subjective discomfort and his age an operation was performed The biceps tendon, rounded off was found in a proximal position enclosed in a synovial sack filled with synovia The biceps muscle was reconnected to the proximal radius by means of a fascia lata graft (Kalnberzs & Veisman 1975 see Figure 1)

Postoperative plaster treatment was maintained for 5 weeks The patient went back to work 3 months after the operation, by which time elbow function was restored to normal

Case 4 A 56 year old man experienced sudden pain in the left upper arm whilst lifting a heavy object Rupture of the distal biceps tendon was diagnosed and an operation was performed in the acute phase the tendon being re attached by suturing through a hole drilled in the radius When the patient returned to work 3 months later he reported a slight loss of gross muscle power in the elbow but otherwise everything was normal

Case 5 A 53 year old man experienced sudden pain in the left upper arm while playing hand ball An operation was performed in the acute phase the tendon being re inserted into the radial tuberosity with pull out sutures through drill holes according to Bunnell (see Figure 2) He took 3 months sick leave and had a completely acceptable result at follow up 6 months after the operation

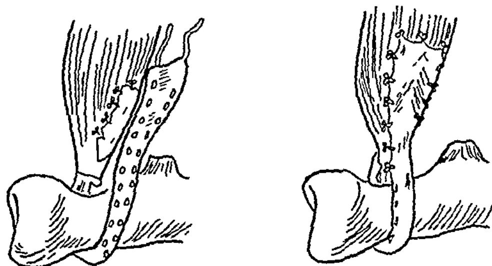


Figure 1 Repair of the biceps muscle with fascia lata (from Kalnberzs & Veisman 1975)

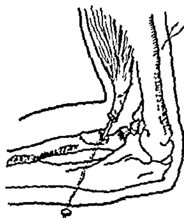


Figure 2 Re-attachment of the tendon to the radial tuberosity by means of a pull out suture (from Lange 1969)

DISCUSSION

A rupture of the distal attachment of the biceps muscle is relatively uncommon of all ruptures to the biceps tendons, only about 3 per cent are reported to occur in the distal portion (Hempel & Schwenke 1974) The patients are mostly men (Postacchini & Puddu 1975) and generally around 50 years of age This is borne out by the cases presented here The cause is held to be a combination of degenerative processes in the tendon and trauma (Postacchini & Puddu 1975 Hempel & Schwenke 1974) But it is noteworthy that the rupture occurs at the bony attachment and seldom leaves any tendon tissue distally

Opinions about treatment vary Most of the results reported in the literature concern surgical cases Early operation carries a good prognosis Here the generally accepted method involves re inserting the distal tendon into the tuberosity of the radius by means of holes drilled through the radius (see Figure 2)

Pull-out suture according to Bunnell or embedded suture can be used According to Postacchini & Puddu, re insertion may lead to radial paresis even when performed in the acute phase and they simply suture the tendon to the brachialis muscle Kalnberzs & Veisman (1975) use a free fascia lata graft, looped round the shaft of the radius and attached at both ends to the biceps tendon (Figure 1)

Postacchini & Puddu, who reported seven cases with suture of the tendon to brachialis considered that this simpler method gave excellent results, including an entirely satisfactory restoration of

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Postoperative plaster treatment was maintained for 5 weeks The patient went back to work 3 months after the operation by which time elbow function was restored to normal

Case 4 A 50 year old man experienced sudden pain in the left upper arm whilst lifting a heavy object Rupture of the distal biceps tendon was diagnosed and an operation was performed in the acute phase the tendon being re attached by suturing through a hole drilled in the radius When the patient returned to work 3 months later he reported a slight loss of gross muscle power in the elbow but otherwise everything was normal

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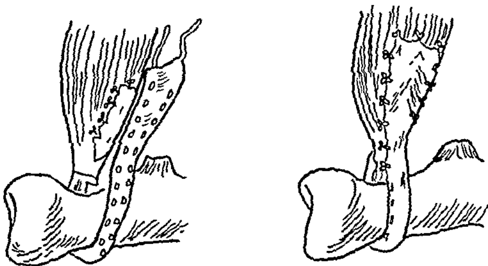


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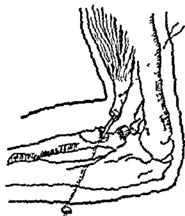


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ıpınatıon Their patients included two hletes, who resumed their sport with-ıt discomfort

In inveterate cases, surgery is an open ıestion In the present case (No 3) the ›eration revealed a synovial sack, con-ınıng about 5 ml of synovia, around e ruptured tendon Presumably this as partly responsible for the patient s ersistent discomfort 3 months after the jury In this instance a good result was hieved with surgery acording to Kaln-erzs

Of the two patients given conservative eatment, one suffered from persistent validism and loss of strength in the m, while the other had substantial sub-ctive discomfort but little objective loss strength

onclusion

Rupture of the distal biceps tendon ıould be operated on in the acute phase, and the tendon re-inserted into the radial tuberosity or sutured to the brachialis muscle An operation can be considered up to 3–4 months after the injury in persons of up to middle age, the method being either a fascia lata graft according to Kalnberzs or suture of the tendon to the brachialis muscle

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OSTEOMYELITIS OF THE SPINE

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A study of a series of 82 cases of pyogenic osteomyelitis of the spine has shown that the clinical features at the initial stage of the disease often present such a varied picture that the correct diagnosis may easily be overlooked for a long time Once radiographic changes are demonstrated the primary consideration in differential diagnosis is tuberculous spondylitis Bacteriological verification by needle biopsy or surgical exploration is recommended in order to institute an adequate antibiotic therapy Surgical evacuation is advocated in cases with extensive vertebral destruction The majority of patients recovered within 1 year from the onset of illness In slightly more than half of the cases the spinal lesions healed with spontaneous interbody fusion This tendency was most pronounced in cases of cervical and upper thoracic involvement No deaths occurred as a result of the spinal disease

Key words clinical course osteomyelitis of the spine prognosis symptoms treatment

Accepted 28 ii 77

Up to a few decades ago tuberculous spondylitis accounted for the majority of the inflammatory conditions involving the spine diagnosed in Sweden During recent years the picture has changed and tuberculous spondylitis has become relatively uncommon whereas osteomyelitis of septic origin has increased in frequency (Figure 1) The symptomatology of pyogenic osteomyelitis of the spine has been described by several earlier authors (Wilensky 1929 Kulowski 1936 Guri 1946 Alvik 1951 Garcia & Grantham 1960 Robinson & Lessof 1961 Ambrose et al 1966 Paus 1973 among others) It is obvious that the condition presents diagnostic pitfalls and is difficult to differentiate from other diseases especially tuberculous spondylitis Whereas earlier studies of pyogenic osteomyelitis of the spine have mainly dealt with the symptomatology and diagnostic features of the disease relatively little interest has been devoted to the clinical course and late results

The present study was undertaken to illustrate diagnostic problems on the basis of a clinical material and to present an account of the clinical course and prognosis in pyogenic osteomyelitis of the spine

PATIENTS

The clinical material comprises 82 cases of haematogenous pyogenic osteomyelitis of the

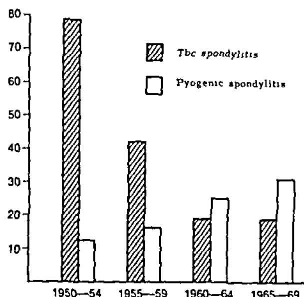


Figure 1 Distribution of cases admitted to the Orthopaedic Department, St Göran's Hospital, and diagnosed as tuberculous spondylitis or pyogenic osteomyelitis of the spine during the period 1950–1969

spine treated at the Orthopaedic Department of St Goran's Hospital, Stockholm, during the years 1950–1970 Cases of postoperative vertebral osteomyelitis following disc surgery are not included The series consisted of 52 men and 31 women As seen in Table 1, the male predominance is due to an accumulation of cases in the age groups over 40 years

Level of spinal involvement

In eight cases the osteomyelitic changes were located in the cervical spine In the remainder of the series, the distribution of thoracic and lumbar involvement was largely the same (Table 2) In the vast majority of cases (75 patients) two adjacent vertebral bodies were affected In three cases changes were present in only one vertebral body, in two cases in three, and in two cases in four adjacent vertebral bodies In no case was there any involvement of the arches or spinous processes

Table 1 Age and sex distribution

Age	Men	Women	Total
0–10	1	1	2
11–20	4	7	11
21–30	4	5	9
31–40	4	4	8
41–50	7	3	10
51–60	12	2	14
61–70	13	7	20
71–80	4	2	6
over 80	2	0	2
Total	51	31	82

Table 2 Site of vertebral osteomyelitis

Level of spinal involvement	Number of cases
Cervical	8
Thoracic	32
Thoracolumbar	6
Lumbar	27
Lumbosacral	8
Thoracic and lumbar	1
Total	82

Primary focus

A probable source of bacterial infection could be identified in 33 cases In 19 of them symptoms developed as a direct sequel to a urinary tract infection (Table 3) Forty nine patients were unable to report any previous infection likely to have a connection with their spinal symptoms

The interval between the primary infection and the onset of spinal symptoms ranged from 1 week to 3 months but in the vast majority of cases the interval was between 2 and 3 weeks

Ten patients (12 per cent) in the total series had diabetes mellitus

CLINICAL FEATURES

In all but seven cases the onset of illness was acute or subacute and fever and pain were the two symptoms dominating the initial stage Ten of the patients were hospitalized in an isolation unit with a diagnosis of obscure pyrexia Since back pain in these cases was overshadowed by

Table 3 Primary focus

Urinary tract infection	19
Respiratory tract infection	8
Skin infection	4
Cholecystitis	2
Unknown	49
Total	82



Figure 2 Radiograms of a male 58 years of age A Tomogram 2.5 months after onset shows narrowing of the space between L2 and L3 and destruction in these vertebral bodies No gibbus can be seen A thin layer of new bone is visible anteriorly B Two years later the bone structure is partly normalized Anteriorly there is a bridge of bone between L2 and L3

the fever and general systemic reaction the correct diagnosis was frequently considerably delayed

Most of the patients however had a severe dull backache during the first 1 or 2 months which was aggravated by movement Segmentally radiating pain was very common and frequently led to an erroneous initial diagnosis Two of the cases of cervical osteomyelitis for instance were diagnosed as myocardial infarctions and admitted to an internal medical unit In cases of osteomyelitis involving the thoracic or lumbar spine abdominal pains frequently dominated Eleven patients were referred to a general surgical unit as acute abdominal cases and in three cases laparotomy was performed (in one case for suspected ileus and in two cases for suspected appendicitis) In cases of osteomyelitis involving the lower lumbar spine sciatic pains in one or both legs were not uncommon

Objective findings at the acute stage were muscle spasm and rigidity in the affected spinal region Distinct percussion tenderness over the spinous processes of the affected vertebrae was an almost constant finding Sciatic pains were not at any time associated with signs of neurological deficit Four patients (5 per cent) in the total series developed paraplegia after an interval of 2 4 5 and 6 weeks respectively from the onset of illness

Laboratory findings

In most cases ESR was strongly elevated during the first months of the disease In 31 cases the highest recorded value exceeded 100 mm/h and in 62 cases 50 mm/h

The antistaphylolysin titre was determined in 76 cases and was increased (more than 2 0 IE) in 36 patients In 12 cases peak values of more than 16 0 IE were recorded

Radiographic findings

The earliest radiographic changes in the majority of cases seen from 2 to 8 weeks after onset were paravertebral soft tissue swelling narrowing of the disc space and superficial destruction of the end plates of adjacent vertebral bodies (Figures 2 and 3)

DIAGNOSIS

The diagnosis was in 20 cases confirmed by bacterial culture of specimens obtained either directly from the spinal focus of infection or from a paravertebral abscess In ten cases the specimen was obtained by needle biopsy and in the remaining ten cases at operation In most of these cases additional histological examination was performed and showed a non specific inflammation



Figure 3 Radiograms of a male, 42 years of age A Tomogram 2 months after onset shows extensive destruction in the adjacent parts of Th7 and Th8 and a slight gibbus B Seven months after onset the intervertebral space is bridged by bone, but the bone structure is still irregular

In another 17 cases the diagnosis was confirmed only by histological findings after routine bacterial culture, tubercular culture and guinea-pig tests had proved negative

In slightly more than half of the cases (45 patients) histological proof and bacterial culture from the osteomyelitis region was lacking, and in these cases diagnosis was based on the clinical features and the appearance of the radiographic changes Four of the patients in this group had a positive blood culture, and in another five cases, which in all likelihood were secondary to a urinary tract infection a positive urine culture was noted in the records

Needle biopsy was done in 41 cases (4 cervical 18 thoracic and 19 lumbar) and yielded positive results in 20 cases (positive culture and/or histological findings)

Bacteriology

The infecting organism could be identified in 24 cases (Table 4) All but two of the 18 patients with spondylitis caused by *Staphylococcus aureus* had an increased antistaphylolysin titre The primary source of infection in these cases was the urinary tract in four patients, the respiratory tract in four patients a skin infection in three patients, and cholecystitis with a subphrenic abscess in one case In the remaining six cases no primary focus could be established

Table 4 Causative organism

Staphylococcus aureus	18
Staphylococcus albus	1
Escherichia coli	4
Proteus	1
Total	24

TREATMENT

Surgical exploration was performed in 20 cases. In 15 cases osteomyelitis involved the thoracic spine and exposure was made by costotransversectomy in all of these cases In the other five cases the lumbar spine was the site of the osteomyelitic lesion and exposure was made retroperitoneally The purpose of this operation was twofold In the first place it permitted the diagnosis to be verified in cases with inconclusive clinical and radiographic findings and provided the material for bacterial culture to guide the selection of the appropriate antibiotics for continued treatment Secondly in cases with extensive destruction and suspected paravertebral abscesses surgery was undertaken with the aim of speeding up healing by removing infectious tissue In these cases, a tuberculous origin was often suspected In two cases the in

dication for surgery was paraplegia developing as a sequel to osteomyelitis in the thoracic region

The time between the onset of illness and operation varied between 6 weeks and 2 years In ten cases operation was performed within the first 4 months and in all but two cases within 9 months of onset In eight of the operated cases the spinal lesion was found to be at the healing stage and the operation was considered to have had diagnostic value only In 12 cases such a large amount of infectious tissue was removed

The remainder had oedema or merely a diffuse swelling of the paravertebral tissues

Posterior fusion was performed in two cases One of these patients had an atlanto axial osteomyelitis resulting in complete destruction of the odontoid process and instability between the first and second cervical vertebrae A detailed report of this case has been published earlier (Ahlbäck & Collert 1970) In the second case posterior fusion at the level of the eleventh and twelfth thoracic vertebrae was prompted by an unusually protracted course with intractible pain

No serious postoperative complications occurred

Antibiotic treatment

Fifty three patients were treated with antibiotics over a continuous period of more than 1 week Fighteen of these patients were treated for a period of 1 to 3 months and 25 patients for more than 3 months In 29 cases no antibiotic treatment was felt to be necessary

Immobilization

The duration of bedrest has been dictated by the patient s subjective symptoms even though some caution with respect to mobilization has been observed in cases with extensive vertebral destruction A plaster bed was used in only eight cases

CLINICAL COURSE

In about one third of the patients with an acute or subacute onset general malaise and pain were so pronounced during the first 1 or 2 months that they were largely confined to bed In the remainder of the series the acute stage was of shorter duration sometimes less than 1 week. This was followed by a gradual improvement with considerable individual variations in the rate of improvement In assessing the activity of the osteomyelitic process, ESR was used as a guide and on the whole this also reflected the patients' subjective symptoms Occasional brief periods of exacerbation during which the patients complaints were aggravated and a slightly elevated temperature was also noted in some cases were not uncommon Peak ESR and ASTA readings were usually recorded 1 to 2 months after onset

In those patients (64 cases) in which the interval between the onset of illness and normalization of ESR readings (< 15 mm/h) could be determined a median value of 3 5 months (range 2–6 months) was found for cervical, 6 months (range 1–12 months) for thoracic and 7 months (range 1–30 months) for lumbar osteomyelitis

No appreciable difference was noted in the length of the clinical course between patients with increased antistaphylolysin titre and the remainder of the series Peak ESR readings recorded in cases of "Staphylococcus osteomyelitis" were significantly higher than in the remainder of the series however

Of the two patients with total paraplegia, in whom operation was performed one case made a complete recovery within 9 months of operation The other patient who had a history of total paraplegia for 3 months prior to operation improved postoperatively but 2 years later still had a partial spastic paraparesis Two other patients who were partially paraplegic were treated conservatively and made a recovery 5 and 20 months after onset, respectively

RESULTS

Sixty-five patients with a follow-up period of more than 2 years (average 6 years) were available for follow-up examination Of the remainder of the series, eight patients had died and nine could not be traced

Subjective symptoms Sixty-one patients were symptom free or had symptoms of such a mild nature that their activities were not appreciably restricted

Two patients reported backache of such severity as to occasion periodical sick leave

One patient had been granted a disability pension because of his back symptoms and one patient still had a partial spastic paraparesis

Three patients had had suspected recurrences with an acute onset of back pain, fever and ESR over 100 *mm/h* Radiographic examination of the back failed to demonstrate any destructive process going on in the skeleton

Objective findings Clinical examination of the back showed a marked gibbus at the level of osteomyelitic involvement in two cases

Radiographic findings The radiographic evidence showed all spinal lesions to be healed at follow-up examination In 33 of the 56 cases included in this follow-up examination, total or partial bony fusion between the involved vertebrae was noted All six of the cervical lesions and 22 of the 29 thoracic lesions had healed by interbody fusion, but this was found in only five of the 21 cases of lumbar involvement When interbody fusion had not occurred, the usual finding was a narrowed disc space with some irregularity in the end plates, but with normal bone structure (Figures 2 and 3)

DISCUSSION

The clinical features of pyogenic vertebral osteomyelitis in its initial stage may present a highly varied picture Referred pain is common and easily tends to lead to an erroneous diagnosis, as evidenced by the present series This risk appears to be greatest when the disease involves the lower region of the thoracic spine or the upper region of the lumbar spine At these levels the clinical picture is often dominated by abdominal pains which may suggest an acute abdominal condition In urosepsis complicated by vertebral osteomyelitis the symptoms—pain and fever—may for a long time be masked by or be attributed to the primary infection Spinal changes may be seen as early as 2 to 3 weeks after the onset of symptoms, but in other cases 2 or 3 months may pass before any changes can be demonstrated In the present series the correct diagnosis was considerably delayed in several cases by negative radiographs during the first few months

Once radiographic changes have been demonstrated, the primary consideration in *differential diagnosis* is tuberculous spondylitis That pyogenic osteomyelitis of the spine is frequently erroneously interpreted as being of tuberculous origin is demonstrated by the present series, in which no less than 28 of the 82 patients were referred to this department with a diagnosis of tuberculous spondylitis In 11 of these cases antituberculous chemotherapy had been initiated The differential diagnosis may sometimes present difficulties, but in our experience many of the clinical and radiographic findings in pyogenic osteomyelitis of the spine are sufficiently characteristic for the correct diagnosis to be established in the majority of cases once radiographic changes can be detected (Ahlback et al 1969 1973)

Malignancy was suspected in a few cases, which radiologically were characterized by a destructive process wholly or predominantly confined to one single vertebra As a rule, however, differential diagnosis in these cases has presented little difficulty

In contrast to tuberculous spondylitis reports on *surgical treatment* for pyogenic osteomyelitis of the spine are very scarce Most authors consider immobilization and antibiotics sufficient treatment (Garcia & Grantham 1960, Robinson & Lessof 1961 Pollack et al 1964 Weber 1965, Ambrose et al 1966, Griffiths & Jones 1971) Riskó et al (1962), on the other hand, advocate radical evacuation in all cases to ensure reliable healing Even though the end result is the same, we feel that evacuation of foci of infection and abscesses may speed up healing in cases with radiographic evidence of extensive destruction and marked paravertebral swelling Our experience

suggests that such operations will be of greatest value when performed within 3 to 4 months of onset

The incidence of *paraplegia* as a complication to pyogenic osteomyelitis of the spine varied between 4 5 and 13 per cent in reports published during recent years (Alvik 1951, Weber 1965) In our series the incidence was 5 per cent Conservative management is advocated by most authors also in the treatment of this complication and reports on the results of surgical treatment are on the whole lacking. From our experience of surgical treatment of paraplegia secondary to tuberculous spondylitis, we feel that anterior decompression by thoracotomy, or in some cases anterolateral decompression by costotransversectomy, is indicated in paraplegic cases (Fellander 1975) Even though conservative treatment may also lead to the desired result, anterior or anterolateral decompression is in all likelihood a quicker and more reliable way of achieving restitution

The effect of *antibiotic treatment* is difficult to assess However, we may reasonably assume that early and adequate drug therapy will prevent or minimize progress of the destructive changes in the affected vertebrae and thus promote a faster recovery This naturally presupposes that a bacteriological diagnosis is obtained at an early stage of the disease Our experience indic[illegible] cated to varying the drug if no immediate response is effected

The clinical course and late results have been treated very summarily and incompletely in earlier reports on pyogenic osteomyelitis of the spine The high mortality rate recorded in the preantibiotic era (Kulowski 1936) has in more recent studies been reduced to less than 10 per cent (Garcia & Grantham 1960, Ambrose et al 1966) In our series no deaths resulted from the disease With regard to the duration of illness and clinical course, Garcia & Grantham (1960) report that the average time required to return to work in their series was 12 months from onset, and that spontaneous interbody fusion was the rule Robinson & Lessof (1961) noted that there is, in some cases at least, a tendency to spontaneous recovery, but the disease may remain chronic or recur after months or years Weber (1965) found recurrences in 13 per cent of his cases In our series the clinical course was fairly similar in the majority of cases with an apparently strong tendency to spontaneous healing A noteworthy finding is that the *period* of illness tended to be shorter and interbody fusion more common in cases of cervical involvement than when other levels were involved The risk of recurrence would seem to be small In our series suspected recurrences were noted in three cases (4 per cent)

Earlier authors (Felländer & Lindberg 1966, Defiore et al 1970) have shown that scintimetry may be of value in determining whether or not a spondylitic process is active In our series the method was adopted for that purpose in a limited number of cases, but it cannot be used as a diagnostic tool to differentiate pyogenic osteomyelitis of the spine from tuberculous disease or cancer

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LIMB BLOOD FLOW IN THE PRESENCE OF A TOURNIQUET

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There is little accurate data on the blood flow to a limb distal to the site of application of a tourniquet This has been studied in Rhesus monkeys with 50 μ diameter microspheres labelled with ^{51}Cr and by the washout of ^{22}Na injected into the tissues One limb was exsanguinated and the circulation occluded with a pneumatic tourniquet and the opposite limb used as a control The results show that blood flow to the occluded limb is less than 1 per cent of the flow to the control limb It is unlikely that this relieves the ischaemia in any way as has been suggested

Key words blood flow, ischaemia, limb, tourniquet

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It has been suggested that despite the application of a tourniquet to the proximal portion of the upper or lower limb, as is the practice in orthopaedic operations, blood may flow into the limb by way of the medullary canal This may result after 30 minutes in an ooze into what was previously a dry field (Furlow 1971) Measurements of this blood flow have been made both experimentally in rabbits and at operation and the amount of blood by passing the tourniquet has been recorded as varying from 1 26 per cent of the total flow to the unoperated limb (Spira et al 1965) This circulation has been described as a factor in relieving the ischaemia produced by the tourniquet and to be of help in prolonging the period it is safe to keep it in place

In order to clarify the situation, an investigation has been carried out on Rhesus monkeys These animals were chosen because of their anatomical similarity to the human subject The questions posed were How much blood reaches the distal end of a limb with a tourniquet occluding the arterial inflow, and under these conditions, what is the extent of venous return?

MATERIAL AND METHODS

In the first series of animals, radioactive microspheres about 50 μ in diameter, were used to study blood distribution because they are almost completely extracted from the blood as it passes through the capillary bed (Wagner et al 1969) The second series of animals was studied using ^{22}Na, plus the local clearance of a diffusable tracer, injected into tissue At low flow rates, the washout rate provides an index of the blood perfusion (Kety 1949) ^{22}Na was also used to estimate the venous return from the limb

Rhesus monkeys were anaesthetised using nitrous oxide, halothane and oxygen The limb under

[illegible]

of mercur

either up

intra arterial blood pressure in the aorta in Rhesus monkeys have shown a range similar to

man 175–110/95–65 mm of mercury with an average of 134/76 (Werdegar et al 1964) and 136–117/84–71 mm of mercury (Forsyth & Baireuter 1967)

In the first series of animals, a catheter was passed into the left ventricle under radiological control and 10^6–10^7 particles (Tracer Sephadex 50 Pharmacia, Uppsala, Sweden) labelled with ^{51}Cr (Radio Chemical Centre, Amersham) in 0 3–1 0 ml were injected over a period of 20–40 seconds The catheter was flushed with 5 ml of isotonic saline and a bolus of 5 ml of radiopaque contrast medium was used to check that the catheter was still in place and therefore that material from the catheter was well mixed before entering the aorta

The activity in the syringe was measured before and after injecting the particles and the activity in the catheter was measured after it had been withdrawn The external measuring system consisting of two 7 5 diameter × 5 cm thick sodium iodide scintillation detectors with 5 cm thick lead collimators was used to measure the activity in the extremities of the monkey as well as the injected dose The effects of background from the trunk of the monkey was reduced by fixing a lead screen between it and the detectors, passing the limb through a 5 cm wide slot in the screen After each measurement, a background reading was taken with the limb moved to a position just outside the lead screen In each experiment the fraction of cardiac output to the region of the limb with the tourniquet was compared with a similar region on the opposite limb as a control Measurements were made on six animals, i e five hands, five forearms, three feet and three lower legs

Two animals were sacrificed after the particles had been injected In these experiments an arm and a leg were occluded with tourniquets and the catheter was passed via the carotid artery When external measurements were complete the animal was dissected The hands, feet, lower leg muscles forearm muscles, tibiae, lungs, liver, spleen and kidneys were placed in sealed plastic pots and then measured in a bulk sample counter (Cronquist et al 1975) This consisted of two 12 5 cm diameter × 5 cm thick sodium iodide detectors completely surrounded by lead 5 cm thick The activity of the syringe before and after injection and the activity of the catheter were also measured in this detector system In one animal, the upper and lower halves of the humerus and femur were counted separately Samples of muscle (about 5 g) were placed in stoppered bottles with formalin, balanced weights of the shaft of the tibiae were placed in similar bottles and the samples counted using a gamma ray counter incorporating *a well type sodium iodide crystal* (LKB Wallac) The control samples were counted until 10 000 coun[ts] had been accumulated and the samples from t[he] limbs which had been occluded by tourniqu[ets] were counted for 1,000 seconds

The sodium washout and venous return fro[m] a limb with an occluding tourniquet was stud[ied] in two animals Approximately 1 5 μCi of ^{22}N[a] was injected into the muscle of the leg distal [to] the tourniquet One of the 7 5 cm diamet[er] sodium iodide detectors was placed over the si[te] of injection and the activity was monitor[ed] using a ratemeter and chart recorder as well [as] a scaler and timer Blood samples were tak[en] from the inferior vena cava at regular interva[ls] for 1 hour The detector was then transferred to a similar region of the control limb and approximately 1 5 μCi of ^{22}Na was injected into the corresponding muscle The activity was monitored until it fell to about half of its initial value, whilst blood samples were taken at frequent intervals

The detector was returned to the limb with a tourniquet, the tourniquet released, and the activity monitored whilst blood samples were taken This experiment was repeated on one further animal to investigate the possible return of blood by way of the medullary circulation In both limbs the ^{22}Na was injected into the medullary cavity of the distal end of the femur through a small hole drilled through the articular surface of the distal surface of the femur

RESULTS

The average of 17 external measurements of control feet, hands, lower legs and forearms was 1 7 per cent of the injected dose with a standard deviation of 1 2 per cent The activities of the corresponding regions of the limbs with tourniquets were expressed as a percentage of the control regions and gave a mean of 3 1 *per cent with a scatter from* 0 3 to 15 per cent

The radioactivity of parts of limbs that were removed for counting in the *bulk* sample counter are summarised in Table 1 The results of measurements made in the well-type counter are shown in Table 2, where only the percentage of *an equiv*alent weight from the control side could be calculated

In Table 3, the activities of the major organs are used to calculate the per-

Table 1 Dissected animals Microspheres Activity of parts of the limb with tourniquet as a percentage of the count rate from the corresponding part of the control limb

Animal no	1	2
Time from injection to death	5 min	1 h 30 min
Hand	0 05	0 24
Arm muscle	0 4	1 16
Foot	0 01	0 69
Leg muscle	0 3	0 55
Tibia	0 01	0 76
Radius		0 76
Mean	0 15	0 69
Standard deviation		0 3
Upper humerus		87
Lower humerus		8
Upper femur		92
Lower femur		18

centage of cardiac output reaching the individual organs The figures are compared with those obtained by Hoffbrand & Forsythe (1969) and Forsythe et al (1968)

Table 2 Dissected animals Microspheres Samples counted in well type counter Count rate of samples from limb with tourniquet as a percentage of control

Animal no	1	2
Arm muscle	0 5	0 96
Leg muscle	0 1	0 26

The external measurements of ^{24}Na are in Table 4 The values of the half periods during the period of occlusion suggest a

Table 3 Dissected animals Microspheres Major organs of the body

Animal no	1		2		Earlier results Forsyth et al (1968) ($n = 13$) Hoffbrand & Forsyth (1969) ($n = 42$)					
	% body weight	% dose	% body weight	% dose	% body weight	S D	% dose	S D	% dose	S D
Liver	4 2	6 1	3 1	8 6	4 4	0 8	4 6	3 8	4 8	3 2
Spleen	0 8	2 6	0 6	6.3	0 2	0 1	1 9	1 2	2 5	1 4
Kidneys	1 2	21 0	1 1	6 2	0 7	0 1	12 3	3 1	15 7	3 7
Lungs	3 1	6 1	2 9	4 3	1 1	0 7	0 5	0 6	0 9	0 9

Note Forsyth et al (1968) and Hoffbrand & Forsyth (1969) measured unanaesthetised monkeys that were sitting in a restraining chair The animals that we studied were anaesthetised and supine and this may account for the difference in lung uptake

Table 4 Washout of ^{24}Na

Animal no	3	4	5
Site	Leg muscle	Leg muscle	*Femur*
Tourniquet (T½)	50 h	Zero slope	25 h
Control (T½)	23 min	11 min	2 4 h
Control T½ as % tourniquet T½	0 8	0	9 5
After release (T½) (1)		2 8 min	6 3 min
After release (T½) (2)		14 1 min	3 9 h
Control T½ as % tourniquet T½		78	62

The half [illegible] log counts/second against time Tour[illegible] ontrol an injection into the cor respo[illegible] after release (2)' are the slopes imme[illegible] and when the limb had recovered from hyperaemia

muscle blood flow of less than 1 per cent of the control No measurements were possible after release of the tourniquet on animal No 1, because it went into a state of shock

Table 5 Blood samples taken during washout of ^{22}Na

Animal no	3	4	5
Tourniquet			
counts/1000s	391	378	390
standard deviation	32	16	13
no of samples	4	5	7
background	366	372	333
Control			
peak × 1000	25 4	21 5	5 9
at (min)	10	2	0 5
plateau × 1000	5 6	5 8	3 5
at (min)	25	31	27
Release			
peak × 1000		24 1	12 5
at (min)		2	2
plateau × 1000		7 8	4 3
at (min)		21	28

Table 5 gives the measurements on blood samples There was no detectable return of isotope from intramuscular injection to the leg of the animal but there was a significant return, less than 0 1 per cent of the control, from the distal end of the femur The slow flow that carried away the isotope must therefore have been into the lower part of the limb When isotope was injected into the control limb, a peak of activity was detected in blood samples and this was followed by a slowly decreasing level This 'plateau' level can be compared with 2 standard deviations of the background count in setting an upper limit to the venous return

DISCUSSION

Measurements of the radioactivity of isolated segments of the sacrificed animals suggest that all *in vivo* radioactivity measurements gave results which were too high This was probably due to the difficulty in screening the occluded limbs from the activity in the rest of the body When 10^6 particles were injected very few reached the limbs with the tourniquet For example, in the isolated foot of animal No 1 the number of particles was of the order of 10, whilst in the samples of muscle, there were less than 5 For this reason long counting times at low background do not substantially improve the accuracy of measurement

Buckberg et al (1971) showed that statistical errors due to the random distribution of particles are an important source of error when the number of particles present is less than 500 In order to produce this number in the limbs to which tourniquets had been applied in a further experiment, approximately 10 particles were injected into the left ventricle The results of this experiment confirm that the blood flow to the limb with a tourniquet is small and does not exceed 1 per cent of that of the control limb

The experiments with ^{22}Na confirm that there is negligible venous outflow past the tourniquet and that the perfusion of muscle distal to the tourniquet is very small The measurements on the muscle consisted of digital counts of approximately 40,000, so that the standard deviation due to statistical fluctuation was 0 5 per cent The series of counts remained within ± 2 standard deviations on both animals for 1 hour A least squares fit to the set of digital counts gave a slope corresponding to a half period of 50 hours on animal No 6 and zero slope on animal No 4 This makes the upper limit of the blood perfusion about 0 7 per cent of the unoccluded value

The blood samples confirmed that no blood was detected leaving the limb with a tourniquet, in this case the minimum detectable activity from the limb with a

tourniquet was 2 standard deviations (10 per cent) of the background The upper limit of venous return from the limb with a tourniquet was therefore about 0 2 per cent of that from the control limb

When isotope was injected into the distal end of the femur, the venous return was still less than 1 per cent of that from the control limb

The amount of blood flow detected here is not likely to be significant for the relief of ischaemia and the limb is virtually isolated from the circulation The result obtained does not totally differ from those of Spira et al (1965) because of the difference in technique These workers injected ^{51}Cr labelled red blood cells and compared tourniquet and control limbs after 3 hours If less than 0 5 per cent of cardiac output reached the limb with a tourniquet there could be a build up of activity to the levels they reported particularly if venous outflow was completely stopped

In our experiments the uptake of microspheres was measured from one passage so that the input to the limb with a tourniquet consisted of a bolus rather than a continuous supply Under these conditions the number of microspheres detected is directly related to the blood flow to the limb

Conclusions

1 The amount of blood reaching the limb distal to a tourniquet is less than 1 per cent of the blood flow to the control limb
2 The venous return is less than 0 2 per cent of that of the control limb
3 The limb with a tourniquet is virtually isolated from the circulation so the amount of blood reaching the tissues is not likely to be significant for the relief of ischaemia

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ENDOPROSTHESIS AS TREATMENT FOR NECROSIS AND PSEUDARTHROSIS AFTER TRANSCERVICAL FEMORAL FRACTURES

A Clinical Review

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This report concerns 105 patients who developed painful necrosis or pseudarthrosis after nailed transcervical femoral fractures and were treated by Moore's arthroplasty The mean age at the time of secondary arthroplasty was 68 years, the operation being performed on average 2 years after the fracture and nailing The mortality within 6 weeks of operation was 3 per cent Complications not producing late sequelae were seen in 11 4 per cent of cases, and complications producing late sequelae occurred in 5 7 per cent At the follow up examination 2 to 8 years after arthroplasty (mean 3 7 years), 37 per cent of the patients were completely free from pain, and the functional result was acceptable in 91 per cent The remaining 9 per cent had other debilitating illnesses The results are compared with other reports in the literature

Key words femoral neck fractures, pseudarthrosis of femoral neck necrosis of femoral head, hip joint, joint prosthesis, arthroplasty postoperative complications, follow-up studies

Accepted 1 iii 77

According to many reports, the reduction and nailing procedure for fracture of the femoral neck is followed by complications in up to 50 per cent of cases (Tillberg 1976) Pain is not always present despite pseudarthrosis or necrosis of the femoral head, and some authors claim that only about half of these patients suffer any discomfort (Hierton et al 1965) Thus roughly one patient out of every four with a nailed femoral neck complains of symptoms requiring further treatment (Johansson 1964) The usual management is hemiarthroplasty using a Moore or Thompson endoprosthesis Many reports have appeared of the late results of arthroplasty in general, but little has been published solely on the subject of secondary arthroplasty

PATIENTS AND METHODS

During the period 1963–1968, 105 patients with pseudarthrosis or necrosis of the femoral head after nailing of femoral neck fractures were treated by arthroplasty at the Orthopaedic Hospital Härnosand Sweden (Table 1) The patients were referred from several general surgical clinics and the true incidence of complications among the total number of femoral neck fractures could therefore not be calculated The age distribution of the patients at the time of hemiarthroplasty is given in Figure 1

The indications for arthroplasty were excruci

ating pain on weight bearing and night pain disturbing sleep The incidence of slipped nail pseudarthrosis and necrosis of the femoral head is shown in Table 2 The group slipped nail includes early complications where pseudarthrosis or necrosis of the femoral head could not be confirmed by x ray whereas pseudarthrosis includes later complications with no signs of necrosis of the femoral head The group necrosis of the femoral head includes patients with x ray signs of necrosis and also some with both necrosis and pseudarthrosis The incidence of late sequelae after nailing according to Pauwels grouping (Pauwels 1935) is shown in Table 3

Table 1 One hundred and five patients treated by Moore arthroplasty because of late complications of nailing

Age (years)	mean	68
	range	44–87
Sex	women	89
	men	16
Side	right	55
	left	50
Follow up time (years)	mean	3 7
	range	2–8

Table 2 Indications for Moore arthroplasty

	No of patients
Slipped nail	10
Pseudarthrosis	41
Necrosis of femoral head	54
Total	105

Table 3 Classification of the patients according to Pauwels groups

Group	I	II	III
Slipped nail and pseudarthrosis	0	16	35
Necrosis of femoral head	0	22	32
Total	0	38	67

Moore s self locking prosthesis was employed in every case using Moore s southern approach technique (Moore 1957) The femoral neck was divided at the appropriate angle when possible one cm above the lesser trochanter in order to avoid shortening the leg The capsule and lateral rotaters were also sutured. To start with the patient was kept in bed for a week after operation As more experience was gained, weight bearing and physiotherapy including walking exercises were started the day after operation The patient was discharged from hospital as soon as everyday activities were possible or on average 5 weeks after operation (range 3–12 weeks) Fifty eight patients remained in hospital for less than 6 weeks

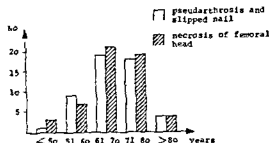


Figure 1 Age distribution

Of the 105 patients operated upon three died within 6 weeks of operation Subsequently a further 15 patients died from causes unrelated to the operation Thus at the time of review 87 patients were available and all were clinically examined by the author 2 to 8 years after operation (Table 1)

RESULTS

Complications during and after operation are shown in Table 4 The figures for postoperative mortality (3 per cent) refer to all patients dying within 6 weeks of operation Other complications are subdivided into those producing and those not producing late sequelae The former necessitated removal of the prosthesis in two patients because of deep infection Mechanical loosening accompanied by pain occurred in four patients, after 18 months to 2 years, and they were successfully treated with a McKee Farrar prosthesis

The interval between nailing and arthroplasty for the whole group was, on average, 24 months (range 4–120 months) For slipped nails the delay

averaged 5 months, for pseudarthrosis 21 months, and for the group 'necrosis of the femoral head' 29 months During this period most of the patients had experienced a great deal of pain and discomfort, and had needed hospital care most of the time

Table 4 Postoperative complications

		No	Per cent
Mortality		3	3
Cardiac	2		
Pulmonary	1		
No late disability		12	11 4
Fracture during operation	3		
Postoperative dislocation	1		
Clinical thromboembolism	3		
Haematoma	3		
Superficial infection	1		
Cardiac infarction	1		
Late disability		6	5 7
Deep infection	2		
Separation of prosthesis with pain	4		

Table 5 shows the incidence of pain at the time of review Thirty-seven per cent of patients were free from pain *Intermittent pain on weight-bearing* means slight or moderate pain after walking several hundred metres Intermittent spontaneous pain means pain at rest not disturbing sleep, sometimes claimed to be caused by a change in the weather

Before the hemiarthroplasty none of the patients were able to work, and many needed institutional care The patients' occupations or activities at the time of the follow-up examination are given in Table 6 Of the 87 patients, 57 were old age pensioners, so their only work was household duties or taking care of themselves, even though some would have been capable of more Eight were in nursing homes, six because of senile dementia or cerebral lesions, one with rheumatoid arthritis, and one with multiple sclerosis

The ability to climb a staircase and to put on shoes and stockings is shown in

Table 5 Pain at time of follow-up examination

	Pseudarthrosis	Necrosis of femoral head	Total per cent
No pain	18	14	37
Intermittent on weight bearing	11	20	36
Intermittent spontaneous	9	8	20
Severe pain	3	4	7
Total	41	46	100

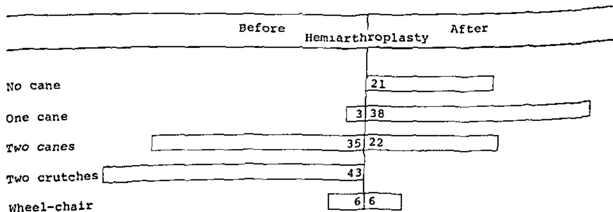


Figure 2 Mobility

Table 7 The unaided walking capacity before operation and at follow-up is shown in Figure 2 Many of those using one stick did so because of the surgeon's recommendation All wheel-chair patients had other incapacitating diseases

Table 6 Occupations

	No
Heavy work	5
Household work	42
Daily activities	32
Institutional care	8
Total	87

Table 7 Activities of daily living

	Yes	With some difficulty	No
Climbing stairs	49	25	13
Putting on shoes and stockings	59	19	9

DISCUSSION

The late results of hemiarthroplasty have been dealt with in many reports, but most investigations have been concerned with mixed series comprising both primary and secondary arthroplasties The results reported here are worse than those in mixed series (cf Beck 1968 and Furey et al 1961 who both report good results in 82 per cent) and still worse than the results of primary arthroplasty (Hinchey & Day 1964 Riska 1971, Tillberg 1976) The results of hemiarthroplasty for necrosis of the femoral head reported here compare well with the poor results reported in cases of coxarthrosis (Apley et al 1969, Andersson et al 1964) Osteoarthrosis develops sooner or later after pseudarthrosis and especially after necrosis After 2 years, or at about the time the lesion can be seen on x ray, 30 per cent of hips with necrosis of the femoral head have developed arthrosis (Bohler & Ender 1953). It thus seems that when a long interval has passed between the primary fracture and the arthroplasty, total arthroplasty is to be preferred, especially when necrosis of the femoral head is present The state of acetabular cartilage should be carefully inspected at operation in every case, and if some defect is discovered a total prosthesis probably should be inserted

Under certain circumstances hemiarthroplasty should be the primary treatment of femoral neck fractures (Lunceford 1965, Riska 1971, Tillberg 1976) Of the 105 patients in this series, 45 were over 70 years of age, and, as Barnes (1970) has reported, the rate of nonunion closely parallels the severity of osteoporosis These patients or 43 per cent of the total series, could have been spared not only the second operation but also roughly 2 years of disability often requiring hospitalization Many debilitating illnesses also increase the rate of non union (Johansson 1964) Of those younger than 70 years 23 patients (22 per cent) suffered from other illnesses and might have been spared a second operation (Tillberg 1976) In addition to the arthroplasty most of the patients had undergone at least two previous operations, i e, nailing and subsequent removal of the nail Sixty seven per cent of the series could be classified into Pauwels' group III fractures (a fracture line at an angle of 70° or more to the horizontal) Such fractures show a high incidence of non-union (Scheck 1965) In Pauwels' group III fractures, and possibly also in group II fractures, primary hemiarthroplasty ought to be seriously considered

In this series of secondary hemiarthroplasties the complications occurring during or immediately after operation, such as dislocation, fracture, thromboembolism, and infection are similar to those reported elsewhere (Moore 1957, Furey et al 1961, Hinchey & Day 1964), and

also to those in primary arthroplasties (Riska 1971, Tillberg 1976) The postoperative mortality is a little lower than in series dealing with primary arthroplasty (Tillberg 1976), but this might be due to the more advanced age of patients treated by primary arthroplasty

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STRESS RADIOGRAPHICAL MEASUREMENTS OF POST-TRAUMATIC KNEE INSTABILITY

A Clinical Study

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In a prospective, consecutive clinical and stress radiographical study comprising 153 traumatic knee injuries the value of stress radiographical measurements gonylaxometry, was studied Clinical evaluation gonylaxometry and preoperative evaluation under general anaesthesia were carried out in that order Then the operative findings were recorded as drawings on standard diagrams These were used as a basis for evaluation of the preoperative tests Of all the methods evaluated, gonylaxometry was found to provide the most accurate information regarding the knee injury Very close to this result were the findings under general anaesthesia. Anterior drawer sign was measured gonylaxometrically when damage to the anterior cruciate ligament was present, posterior drawer meant damage to the posterior cruciate ligament Partial ruptures of cruciate ligaments did not allow antero-posterior displacements exceeding the critical levels of the test. Small positive medial instability was found with ruptures of profound medial structures, higher values with total rupture of the long superficial collateral band, and still higher values when cruciate ligament ruptures were also present. The predictive values of a positive radiographical test were 100 per cent as regards medial instability and 98 per cent for drawer looseness The predictive values of a negative test were 96 per cent for drawer and 92 per cent for medial instability These figures are based on the total material 95 per cent confidence limits are given

Key words knee instability, gonylaxometry, predictive values prospective clinical evaluation, stress radiography

Accepted 9 ii 77

A method for stress radiographical measurement of anterior, posterior and medial and lateral stability in the knee joint has been described by the author (Jacobsen 1976) A series of subjects with healthy knees were used to investigate the accuracy and upper limits of the normal standard values of the

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also to those in primary arthroplasties (Riska 1971, Tillberg 1976) The postoperative mortality is a little lower than in series dealing with primary arthroplasty (Tillberg 1976), but this might be due to the more advanced age of patients treated by primary arthroplasty

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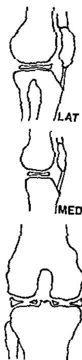


Figure 1 Diagram for routine drawings of ligament and capsule ruptures found at operation

at 90° of knee flexion with the foot fixed pointing anteriorly (starting from 'neutral position 90°) a force of 30 kg being applied (Measurement of rotation will be dealt with in a following publication) Medial and lateral instability as well as anterior and posterior displacements were measured on the radiographs and recorded before operation

Preoperative clinical evaluation was carried out on admission (before gonylaxometry) in 122 of the cases by another senior surgeon (chief or senior registrar) and the results were sealed in 31 cases the clinical evaluation was performed by the author and became the first entry in the patients record Preoperative evaluation under general anaesthesia was carried out, after gonylaxometry in all cases by the author Operative findings were recorded in detail and drawings were made of the findings on standard diagrams (Figure 1)

The clinical evaluation was simplified to include only a description of whether or not instability was present If an attempt was made to use three degrees 1) no instability, 2) a little instability 3) gross instability, the clinical evaluation became very uncertain

The stress radiographical findings were correlated with the operative findings The preoperative clinical findings and the preoperative findings under anaesthesia were also correlated with the findings at operation As expressions of these correlations, the predictive value of a positive test, PV_{pos}, and the predictive value of a negative test, PV_{neg}, are used, as described by Vecchio (1966) and in Scandinavia by Wulff (1976) The PV_{pos} is defined as the probability of a certain ligament injury if the test is positive The PV_{neg} is defined as the probability of non injury if the test is negative

FINDINGS

Group 1

The stress radiographical measurements of group 1 can be seen in Figure 2 Instabilities were measured on the radiographs in millimetres with one decimal and are shown and defined throughout this paper as the differences between the patient's injured and healthy knee In accordance with the earlier measurements on healthy subjects, 2 0 mm is used as the upper normal limit (critical level) for medial and lateral instability and 3 0 mm as the critical level for abnormal anterior or posterior displacement

Patients nos 1 to 11 showed, at stress radiography, no collateral looseness at all, and the measurements were true negative as the operations showed no injuries to the collateral ligaments, but revealed other injuries (of the meniscus or dislocations of the knee cap) Patients nos 1, 2 and 3 had small tears of isolated fibres anteriorly in the superficial medial collateral ligament, this nevertheless being intact in more than two-thirds of its breadth, thus not allowing any looseness in the frontal plane *Nos 12 to 57* represent *isolated injuries to the medial collateral ligaments* At gonylaxometry they all showed true positive values as they exceeded the critical level of 2 mm and true negative values for anteroposterior displacement (<3 mm) Among these, nos 12 to 24 had the smallest

parameters mentioned A logical next step is an investigation of the clinical value on a clinical material A prospective study is presented below comprising preoperative stress-radiographical measurements compared with 1) operative findings, 2) a preoperative clinical evaluation and 3) a preoperative evaluation under general anaesthesia

PATIENTS

The material comprises a prospective consecutive, series of 151 patients with 153 traumatic knee injuries Two patients have been examined and operated upon twice (in the same knee) The investigation took place from January 1974 to November 1975 The age and sex distribution is shown in Table 1, the precipitating activity or cause of the injury is shown in Table 2 There are a great number of young people in the age group 17 to 30 years as the material comprises largely sports injuries The preponderance of men is explained by the great number of soccer injuries

All the patients were referred with a suspicion of ligamentous injury to the knee and all were examined and operated upon They were divided into three groups on the basis of the duration of time from trauma to operation

Group 1 duration 14 days or less (recent injuries)
Group 2 duration from 15 days to 3 months
Group 3 duration exceeding 3 months

The group of recent injuries comprised 90 knee joints Local anaesthesia (Lidocaini chloridum) was necessary during the measurements It was combined with noradrenaline for the collateral ligaments and the capsule but used alone intra articularly (5 ml ½ per cent, after aspiration of hydarthrosis or haemarthrosis) In recent injuries observation of the damage to ligaments and capsular structures is facilitated by the absence of scar tissue On the other hand pain may be violent and so in three of the 90 injuries measurement of anteroposterior instability could not be carried out

Group 2 comprised only 26 knee injuries The use of local anaesthesia was also necessary during stress radiography in this group During operation the patho anatomy of the injuries was blurred by scar tissue and atrophy of the cruciate ligaments

Group 3 comprised 37 knees Here no pain interfered with the measurements and local anaesthesia was not utilized The original patho anatomy of the injuries to collateral ligaments and capsule was totally blurred by scar tissue and injuries to the cruciate ligaments could be graded only as partial or total atrophy Peroperative judgement of any healing with elongation of injured cruciate ligaments is very difficult and uncertain and has been avoided

Table 1 Age and sex of the 153 patients

Age in years	Total	Men	Women
13–20	39	35	4
21–30	69	58	11
31–40	27	23	4
41–50	13	7	6
51–60	3	1	2
61–67	2	1	1
13 67	153	125	28 (18 3 %)

Table 2 Precipitating activity or cause of the injury

Precipitating cause	Total	Men	Women
Soccer	79	76	3
Handball	11	6	5
Other ball games (basketball volleyball badminton)	5	4	1
Skiing	17	7	10
Other sports	11	10	1
All sports total	124	103	21
Work, traffic and holiday accidents	29	22	7
Total	153	125	28

METHOD

The preoperative stress radiographical measurements were carried out as described previously (Jacobsen 1976) viz medial and lateral instability was measured on a-p radiographs with the patient s knees flexed 20° (neutral position 160°) with a 9 kg stress (abduction or adduction) on both knees at the same time Only the gap in the frontal plane was measured this being used as a definition of medial and lateral instability The foot and femur were fixed to avoid rotation The drawer signs were measured

Table 3 Predictive values in knee injuries ≦ 14 days Medial instability

Gonylaxometry TN = 21 FN = 5 TP = 63 FP = 0 N = 89

Predictive value of pos test $= PV_{pos} = \frac{TP}{TP + FP} = \frac{63}{63 + 0} = 100\ \%$
(95 % confidence limits 94 100 %)

Predictive value of neg test $= PV_{neg} = \frac{TN}{TN + FN} = \frac{21}{21 + 5} = 81\ \%$
(95 % confidence limits 61 93 %)

Clinical test TN = 10 FN = 2 TP = 66 FP = 12 N = 90

$PV_{pos} = \frac{TP}{TP + FP} = \frac{66}{66 + 12} = 85\ \%$ (75–92 %)

$PV_{neg} = \frac{TN}{TN + FN} = \frac{10}{10 + 2} = 83\ \%$ (52 98 %)

Test under general anaesthesia TN = 20 FN = 3 TP = 65 FP = 2 N = 90

$PV_{pos} = \frac{TP}{TP + FP} = \frac{65}{65 + 2} = 97\ \%$ (90 100 %)

$PV_{neg} = \frac{TN}{TN + FN} = \frac{20}{20 + 3} = 87\ \%$ (66–97 %)

TN = true negative TP = true positive FN = false negative FP = false positive N = number of patients tested

amount of positive medial instability nearly all of them less than 4 mm and the operative findings revealed ruptures of the deep medial structures i e the profound medial collateral and oblique posteromedial ligaments sometimes together with smaller tears in the superficial medial collateral ligament but never a total rupture of this structure On the contrary patients nos 25 to 57 all (except one) showed greater medial instability (> 4 mm) and they all had a total rupture of the superficial medial collateral ligament which Warren et al (1974) have called "the prime static stabilizer of the medial side of the knee Moreover it can be seen that gross medial and lateral instabilities are found in combination with gross drawer signs (to the right in the diagram Figure 2)

The main purpose of the development of the gonylaxometer has not been for diagnostic use in acute injuries but for scientific use (follow up investigations and investigations of old painless unstable knee joints) However, an evaluation of the method for acute cases ought to be made and so the predictive values, PV_{pos} and PV_{neg} were calculated (Table 3)

Lateral instability In two cases (nos 58 and 59) with operatively proven small incomplete ruptures of the lateral collateral ligament there was no instability The four other cases had grave injuries and positive measurements (Figure 2)

Drawer symptoms in group 1 Anterior drawer range at gonylaxometry was up to 16 mm (difference from the healthy knee) and posterior drawer up to 21 mm The amount of anterior and posterior displacement was evenly spread from the critical levels to the top of the rank Cruciate ligament injuries were found in nos 60 to 90 Three cases with injuries to both cruciate ligaments were measured

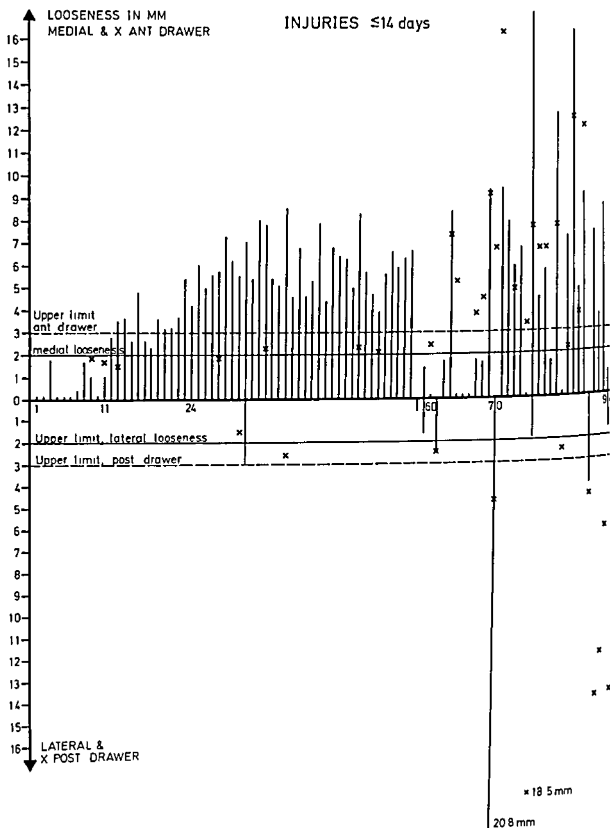


Figure 2 Diagram showing stress radiographically measured instabilities in group 1 Differences between the patient s injured and healthy knee Medial collateral instability columns above the axis of the abscissa Lateral instability columns below the axis Anterior displacement or drawer as an x above the axis and posterior drawer as an x below the axis (values below the axis are thus also positive) Every column and cross show measurements on one patient, the patient number being the abscissa

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$$\text{Predictive value of pos test} = PV_{pos} = \frac{TP}{TP + FP} = \frac{63}{63 + 0} = 100\,\%$$

(95 % confidence limits 94–100 %)

$$\text{Predictive value of neg test} = PV_{neg} = \frac{TN}{TN + FN} = \frac{21}{21 + 5} = 81\,\%$$

(95 % confidence limits 61–93 %)

Clinical test TN = 10 FN = 2 TP = 66 FP = 12, N = 90

$$PV_{pos} = \frac{TP}{TP + FP} = \frac{66}{66 + 12} = 85\,\% \quad (75\text{–}92\,\%)$$

$$PV_{neg} = \frac{TN}{TN + FN} = \frac{10}{10 + 2} = 83\,\% \quad (52\text{–}98\,\%)$$

Test under general anaesthesia TN = 20 FN = 3, TP = 65, FP = 2 N = 90

$$PV_{pos} = \frac{TP}{TP + FP} = \frac{65}{65 + 2} = 97\,\% \quad (90\text{–}100\,\%)$$

$$PV_{neg} = \frac{TN}{TN + FN} = \frac{20}{20 + 3} = 87\,\% \quad (66\text{–}97\,\%)$$

TN = true negative TP = true positive FN = false negative, FP = false positive N = number of patients tested

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The main purpose of the development of the gonylaxometer *has not* been for diagnostic use in acute injuries but for scientific use (follow-up investigations and investigations of old painless unstable knee joints) However, an evaluation of the method for acute cases ought to be made and so the predictive values, PV_{pos} and PV_{neg}, were calculated (Table 3)

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Two showed a marked drawer sign both anteriorly and posteriorly, while one was negative (see below) Injuries to the posterior cruciate ligament without injury to the anterior were found in five patients, all with true positive measurements of posterior drawer *Anterior drawer* could not be measured radiographically in seven cases of partial rupture and in one case of intrasynovial rupture of the anterior cruciate ligament while partial rupture of the anterior cruciate ligament was demonstrated by small values in two cases

Table 4 Predictive values Total a-p displacement (drawer/no drawer) Injuries ≦ 14 days 95 % confidence limits in brackets

Gonylaxometry
N = 87, FP = 0, TP = 21, FN = 10, TN = 56
PV_{pos} = *100 %* (84–100 %)
PV_{neg} = *85 %* (74–92 %)
Clinical test
N = 90, FP = 7, TP = 18, FN = 14 TN = 51
PV_{pos} = *72 %* (51–88 %)
PV_{neg} = *78 %* (67–88 %)
Test under general anaesthesia
N = 90 FP = 2 TP = 21, FN = 11, TN = 56
PV_{pos} = *91 %* (72–99 %)
PV_{neg} = *84 %* (73–92 %)

Two cases with total rupture (one of the anterior and one of the anterior plus posterior cruciate) did not show any drawer sign either at gonylaxometry or during examination under general anaesthesia During operation the femoral condyle was found to be locked in a great bucket-handle-lesion of the meniscus In the calculation of predictive values these 10 cases (including partial ruptures) are considered as false negative

Table 4 gives the values for the patients with total a-p displacement exceeding critical levels If anterior and posterior drawer are separated, the clinical test becomes more inaccurate while gonylaxometry and evaluation under

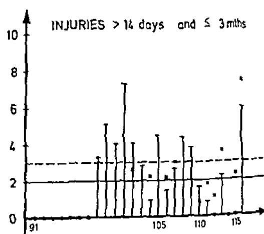


Figure 3 Stress radiographically measured instabilities in group 2 Medial instability column above the axis Anterior drawer, x above the axis No lateral or posterior cruciate injuries in this group

general anaesthesia remains unchanged Table 4 shows the superiority of gonylaxometry also in the acute diagnostic field but this is indeed very moderate compared with examination under general anaesthesia

Group 2 (26 knee joints)

The stress radiographical measurements are shown in Figure 3 There were no cases of lateral collateral or posterior cruciate ligament injury There were no cases of false negative or false positive medial instability, which ranged up to 7 3 mm Four cases of peroperatively verified partial anterior cruciate ligament ruptures could not be demonstrated by gonylaxometry or by examination under general anaesthesia Two out of three total ruptures of the anterior cruciate ligament showed measurements of anterior drawer exceeding the critical level and they were also estimated as positive during clinical examination and examination under general anaesthesia The third case had a negative drawer sign at gonylaxometry as well as during the clinical examination and the examination under anaesthesia This group by itself is too small for statistical analysis

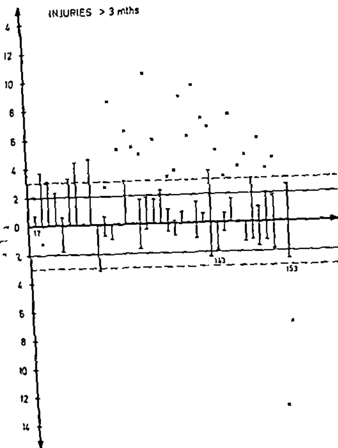


Figure 4 Stress radiographically measured instabilities in group 3 For explanation of indications refer to Figure 2

Group 3 (37 knees)

There was no pain during stress radio graphy and local anaesthesia was not used The measurements can thus be considered to be accurate One bucket handle lesion with locking of the femoral condyle and false negative measurement of drawer was found Figure 4 shows the findings at gonylaxometry Most remarkable is the medial instability which is slight in these chronic injuries (range up to 4 6 mm) In 22 cases no collateral instability at all was found either at gonylaxometry or at operation

One false positive anterior drawer sign (5 mm) was found The patient had a marked quadriceps atrophy following arthrotomy and suture of the medial collateral ligament 2 years earlier, after a work accident He had recurrent hydarthrosis, pain in the knee and a feeling of instability The present operation showed normal structure of the cruciate ligaments, but they were loose

The drawer signs in this group ranged from 3 3 to 15 1 mm, mean 6 6 mm The PV_{pos} = 96 per cent (80–100 per cent) and PV_{neg} = 92 per cent (67–100 per cent) are approximately the same as in group 1

Finally an evaluation of the total material was made As it is normally impossible to detect partial cruciate ligament rupture by this method, as pointed

Two showed a marked drawer sign both anteriorly and posteriorly, while one was negative (see below) Injuries to the posterior cruciate ligament without injury to the anterior were found in five patients, all with true positive measurements of posterior drawer *Anterior drawer* could not be measured radiographically in seven cases of partial rupture and in one case of intrasynovial rupture of the anterior cruciate ligament while partial rupture of the anterior cruciate ligament was demonstrated by small values in two cases

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Clinical test
N = 90, FP = 7, TP = 18, FN = 14 TN = 51
PV_{pos} = *72 %* (51–88 %)
PV_{neg} = *78 %* (67 88 %)

Test under general anaesthesia
N = 90 FP = 2, TP = 21 FN = 11 TN = 56
PV_{pos} = *91 %* (72–99 %)
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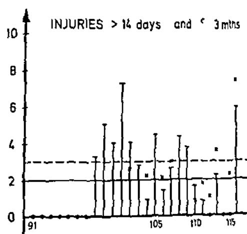


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Group 2 (26 knee joints)

The stress radiographical meas ments are shown in Figure 3 There w no cases of lateral collateral or poste cruciate ligament injury There were cases of false negative or false posi medial instability, which ranged up 7 3 mm Four cases of peroperati verified partial anterior cruciate l ment ruptures could not be demonstr by gonylaxometry or by examination der general anaesthesia Two out of t total ruptures of the anterior cruc ligament showed measurements of terior drawer exceeding the critical l and they were also estimated as posi during clinical examination and ex ination under general anaesthesia third case had a negative drawer sig gonylaxometry as well as during clinical examination and the examinat under anaesthesia This group by itsel too small for statistical analysis

ligament as positive drawer signs exceed ing the critical levels used here There may be an anatomical reason for this The anterior cruciate ligament consists of a posterolateral part, which is taut at knee extension and more slack at 90° knee flexion and an anteromedial part which is taut at 90° knee flexion This fact has been described in anatomical text books (Fick 1904 Lang & Wachsmuth 1972) It was not mentioned by Kennedy et al in their biomechanical work (1974) but has been advanced again by Furman et al (1976) In eight of the cases where measurement of partial anterior cruciate rupture was not possible a rupture of the posterolateral fibres was found leaving the anteromedial fibre bundle which is taut in the position of drawer measurement in the gonylaxometer intact In this situation it is impossible to bring about any anterior drawer sign and these cases ought not to be designated false negative (neither do they offer an indication for operation—see below) Table 4 which counts these ruptures as false negatives thus represents an absolute minimum of the PV_{neg} at stress radiography

Posterior drawer signs were only found coincident with ruptures of the posterior cruciate ligament and anterior drawer signs coincident with ruptures of the anterior cruciate ligament in agreement with the works of Palmer (1938) and numerous others most recently Furman et al (1976) Group 1 also comprises four isolated anterior drawer signs (true positive all with true negative medial instability They represent three total ruptures and one partial and in agreement with Wang et al (1975) contribute to the continuous controversy of whether an isolated injury of the anterior cruciate ligament may occur It does

Thus gonylaxometry in this clinical material shows patterns of instability in agreement with findings of other authors also those who have been working experimentally using fresh human knee specimens Moreover when used as a diagnostic test gonylaxometry must be evaluated in relation to its primary function assessment for operation Those patients in group 1 whose measurements of drawer looseness were false negative ought not to have been operated upon in 8 out of 10 cases as their cruciate ligament ruptures were partial or intra synovial With this background the PV_{neg} could be calculated to 97 per cent (and PV_{pos} 100 per cent) A similar consideration can be made for four out of five false negative measurements on fresh medial collateral ruptures where total rupture of the superficial band not was found Being also a diagnostic aid in acute and other knee injuries gonylaxometry is therefore evaluated as a method of high accuracy

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out above, the *negative measurements of these injuries* are counted as true negative. For total anteroposterior displacement PV_{pos} = 98 per cent (89–100 per cent), PV_{neg} = 96 per cent (90–99 per cent), for *medial instability* PV_{pos} = 100 per cent (96–100 per cent) and PV_{neg} = 92 per cent (83–97 per cent).

DISCUSSION

The main purpose of this report was to show how collateral and anteroposterior instabilities in patients could be measured with relative accuracy by gonylaxometry. It was also important to discover if certain injuries to the ligaments showed certain patterns of instability at stress radiography.

The pattern of medial ligament injuries is shown by stress radiography to agree with that found by Warren et al. (1974). These authors investigated the medial structures in fresh human knee specimens. They have shown that the anterior long fibres of the superficial medial collateral ligament for a breadth of approximately 10 mm are the main stabilizing factors of the medial side of the knee. As mentioned above medial instabilities more than approximately 4 mm at stress radiography cannot be demonstrated unless this part of the ligament has been totally ruptured and if this is the case the instability is > 4 mm. Warren et al. (Chart II) found an increase in instability of 8 mm (mean) in this situation—with intact cruciate ligaments—which matches well with the findings in patients nos. 25, 57 on Figure 2.

Positive findings from 2 to 4 mm indicate ruptures in the deep medial ligaments without total rupture of the superficial ligament (nos. 12, 24). In agreement with Hallén & Lindahl (1965) the very large medial and lateral instabilities are found in ruptures of both cruciate ligaments and the posterior joint capsule in connection with total rupture of the medial or lateral structures (nos. 70 and 76).

The most remarkable finding in the group of chronic injuries is that collateral instability is only slight, in 22 cases there was none at all. This is a fact for both patients with and patients without rupture of cruciate ligaments. This finding indicates that the medial collateral ligament and the capsular structures are capable of spontaneous restitution after trauma even if untreated or treated only by a plaster cast, as found by Jonasch (1958). He measured, at follow-up, the medial instability in the frontal plane using a simple radiographical technique and manual pressure (1200 plaster cast-treated patients). But it must be stressed that this fact tells nothing about rotatory instability and the role of a possible coincident a-p instability.

In the total material three cases of negative a-p measurements were found in which the subsequent arthrotomy showed a "locking" of the femoral condyle to the tibial by a bucket handle lesion of the meniscus. These are all considered as false negative in the statistical calculations. This is justified from a diagnostic point of view but hardly from the point of view of the measuring technique.

The investigation reveals an even distribution of the measured values of all parameters on the scale from the critical levels and upwards. This also applies to the a-p displacements, there being no "free interval" between the upper normal values (97.5 per cent border) and the pathological values. This is to be expected in a biological material with very complex injuries to different ligaments in the joint—the degree of a drawer sign also being dependent on the condition of the other ligaments and the capsule.

Generally it is not possible to measure partial ruptures of the anterior cruciate

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BELOW-KNEE AMPUTATION FOR ISCHAEMIC GANGRENE

Prospective, Randomized Comparison of a Transverse and a Sagittal Operative Technique

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In a prospective randomized study a comparison was made of the results of primary below knee amputation for ischaemic gangrene carried out by two methods In 47 cases by the transverse technique with a long posterior musculo cutaneous flap and in 41 cases by the sagittal technique using equally large medial and lateral musculo-cutaneous flaps—in both instances followed by 2 weeks in a half-open plaster cast with extended knee The sex ratio and age distribution were the same in both groups Minor differences in the vascular condition between the groups, assessed by the duration of rest pain, pulsation findings, extent of gangrene, and frequency of diabetes, wholly or partially equalized each other The course of healing was the same in both groups primary healing being attained in 38 per cent and 41 per cent, respectively ($0.70 < P < 0.80$) There was also no difference between the results as regards limb fitting ambulation, occupational or social status It is concluded that the choice between the two methods can be based merely upon surgical skill and the ischaemic changes in the lower leg

Key words amputation amputation stumps, gangrene, below knee amputation

Accepted 28 ix 76

Increased longevity has entailed an increased number of lower-extremity amputations for vascular diseases (Hansson 1964) Rehabilitation is greatly facilitated by preserving the knee (Sarmiento et al 1970) Recent advances, involving an increased frequency of below-knee as compared with above-knee amputation in ischaemic gangrene, have been obtained with improved pre- and postoperative management (plaster casts, improved and non-traumatic surgical technique, and new surgical methods)

A sagittal technique for below-knee amputations was described by Tracy (1966) and a similar technique by Persson & Sunden (1971) A few years later, Persson (1974) demonstrated the superiority of this technique over the conventional technique of using anterior and posterior flaps

The present prospective, randomized study was designed to compare the results of below knee amputation performed by the transverse technique using a long posterior musculo-cutaneous flap (Bickel 1943, Perry 1963, Romano & Brugess 1971) with the results of Persson & Sundén's sagittal technique

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A sagittal technique for below knee amputations was described by Tracy (1966) and a similar technique by Persson & Sunden (1971). A few years later Persson (1974) demonstrated the superiority of this technique over the conventional technique of using anterior and posterior flaps.

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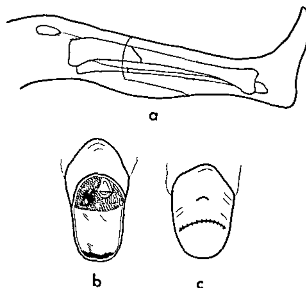


Figure 1 Transverse technique a Skin incision b Posterior flap c Skin closure

MATERIAL AND METHODS

The material comprises all lower extremity amputations done for ischaemic gangrene in the Department of Orthopaedic Surgery O Odense Hospital during the period June 1972 through December 1974 (Table 1) Primary below knee amputation was performed to the widest possible extent if the cutaneous blood supply was deemed sufficient The primary amputation level was distributed as shown in Table 2

Table 1 Total number of lower limb amputations for ischaemic gangrene

Diagnosis	No of patients	No of extremities
Arteriosclerosis	59	66
Diabetes	37	45
Mixed a v insufficiency	1	1
Embolism/thrombosis	4	4
Total	101	116

Table 2 Primary level of amputation for ischaemic gangrene

	No of extremities	Percentage
Foot and toes	5	4
Below knee	88	76
Above knee	23	20
Total	116	100

Primary below knee amputation for ischaemic gangrene was performed on 88 extremities which form the basis of this study

The primary below knee amputation was done by the sagittal technique on all patients whose year of birth was an even number and by the transverse technique on all whose year of birth was an odd number The transverse amputation (Figure 1) utilized one long posterior musculocutaneous flap and no anterior flap in the sagittal amputation (Figure 2) equally large medial and lateral musculo cutaneous flaps were used In both techniques the tibia was cut obliquely and covered with muscle using chromic catgut sutures in the fascia The skin was closed by atraumatic 3 0 nylon sutures As little injury as possible was inflicted on the tissue—in particular the skin—for instance by not applying forceps A half open plaster cast was applied with extended knee Suction drainage was used after transverse amputation and during the latter year of the study period also after sagittal amputation The patients were allowed to sit up on the day after the operation but further mobilization was not allowed until the plaster was removed 2 weeks later Antibiotics were not routinely used

Table 3 gives the distribution of the two operative techniques the sex ratio the mean age and frequency of diabetes in the two groups The age distribution is shown in Figure 3 Table 4 further demonstrates the comparability of the two groups The transverse amputees had a somewhat longer duration of rest pain than the sagittal amputees The sagittal group had somewhat more favourable pulsation findings than the transverse group 27 per cent

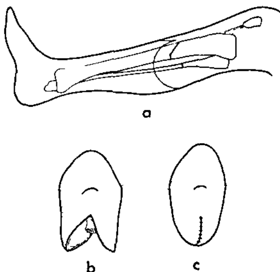


Figure 2 Sagittal technique a Skin incision b Sagittal flaps c skin closure

Table 3 Primary below-knee amputation for ischaemic gangrene

Technique	No of extremities	Men	Women	Mean age (years)	Diabetes
Sagittal (medial and lateral flaps)	41	24	17	70 0	16 (39 %)
Transverse (long posterior flap)	47	22	25	70 5	22 (47 %)

and 13 per cent respectively, having pulsation in the popliteal artery or distal to it Of the sagittal amputees 34 per cent had gangrene in the ankle region or proximal to it as compared with 46 per cent of the transverse amputees Forty six per cent of the sagittal and 34 per cent of the transverse cases were assessed by a vascular surgeon, 22 and 13 per cent respectively had vascular surgery Lastly ambulation occupational and social status were approximately the same in both groups

Table 4 Duration of rest pain extent of gangrene and lowest palpable pulse in patients treated for ischaemic gangrene by primary below knee amputation The figures in brackets give the absolute number of amputations within each group

Duration of rest pain	Sagittal	Transverse
	(41)	(47)
No pain	10 %	13 %
	(4)	(6)
1 month	15 %	15 %
	(6)	(7)
1 3 months	46 %	23 %
	(19)	(11)
3 months	29 %	49 %
	(12)	(23)

Extent of gangrene	Sagittal	Transverse
	(41)	(47)
Toe and forefoot	66 %	54 %
	(27	(25)
Ankle	22 %	38 %
	9)	(18)
Above ankle	12 %	4 %
	5)	(2)
Mid leg	0 %	4 %
	(0)	(2)

Lowest palpable pulse	Sagittal	Transverse
	(41)	(47)
Pedal	5 %	4 %
	(2)	(2)
Popliteal	22 %	9 %
	(9)	(4)
Femoral	63 %	74 %
	(26)	(35)
Aorta	10 %	13 %
	(4)	(6)

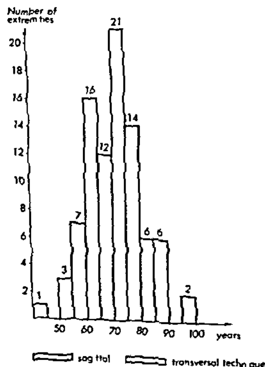


Figure 3 Age distribution of 88 patients treated by primary below-knee amputation

Table 5 Results of primary below knee amputation for ischaemic gangrene

Technique	No of extremities	Healing after primary below-knee amputation		Healing after re-amputation		Died before healing		Not healed at follow up	
		primary	secondary	above-knee	below-knee	above-knee	below-knee	above-knee	below knee
Sagittal	41	17* (41 %)	7 (17 %)	10	1	4	1	0	1
Transverse	47	18* (38 %)	10 (21 %)	7	4	2	3	1	2

* $0.70 < P < 0.80$ (χ^2 test)

RESULTS

All surviving patients were seen at follow-up an average of 11 7 months, range 3 5–22 months, after the amputation Twenty had died before the follow-up examination, but the course of wound healing is known for all There was no difference in primary or secondary healing between the two groups (Table 5)

The re-amputation rate was a poor criterion of the value of the two operative methods, as in some of the cases healing was not obtained after re-amputation

In all, healing at the primary amputation level was attained during the study period by 61 per cent (25/41) of the sagittal amputees and by 68 per cent (32/47) of the transverse amputees, which is 65 per cent of all primary below-knee amputees, but in five of the cases healing was not obtained until re-amputation had been performed The difference between the two groups is not significant ($0.40 < P < 0.50$, χ^2 test) The result was better in diabetics, who exhibited healing at the primary level in 82 per cent, than in the non-diabetics who healed in 48 per cent at the primary level ($0.001 < P < 0.005$)

When considering the total material of extremities with ischaemic gangrene the definitive frequency of below-knee amputation was 55 per cent (64/116), above-knee amputation 41 per cent (47/116), and partial foot or toe amputation 4 per cent (5/116)

The mortality within the first 3 months after the amputation was 17 per cent (8/47) among the transverse amputees as against 10 per cent (4/41) among the sagittal amputees However there was a corresponding imbalance in the frequency of heart disease, viz , 57 per cent and 27 per cent in the two groups

Limb fitting was successful in 78 per cent of the sagittal and in 72 per cent of the transverse amputees Sixty one per cent of both groups were fitted with below-knee prostheses, but the PTB prosthesis could be used by a larger number of the transverse amputees (26/47 = 55 per cent) than of the sagittal ones (18/41 = 44 per cent) who were a little more apt to have stump complaints especially in the form of pressure due to the situation of the scar distally over the tibial stump

Ambulation, occupational and social status were uniformly impaired in both groups as compared with the pre amputation condition At follow-up, 65 per cent (57/88) of all the primary below knee amputees were able to walk on their artificial limb, without assistance by another person Thirteen per cent (11/88) were institutionalized, while 64 per cent (56/88) were living at home

DISCUSSION

Several authors have demonstrated that below knee amputation can be successfully accomplished in more patients with ischaemic gangrene of the lower extremities than previously assumed. For instance Sarmiento et al (1970) comparing two 4 year periods found a significant decrease in the number of re amputations from below knee to above knee level while simultaneously there had been an appreciable increase in the frequency of primary below knee amputations. The improvement in the results coincided with the introduction of immediate post surgical *prosthetic fitting*. A similar advance was found by Persson (1974) when changing from the conventional technique of equally long anterior and posterior flaps to the sagittal below knee amputation technique and theoretical advantages of the new method were given part of the credit. However both studies were retrospective and the methods compared were not used concurrently during the study period. Therefore it cannot be ruled out that other factors may have been decisive.

The present study was designed as a prospective randomized investigation. The assessment of the results depends upon the comparability of the two groups treated. The duration of rest pain, pulsation findings and the extent of the gangrene afford an impression of a more favourable vascular state among the sagittal than among the transverse amputees. In return it might be expected that the influence of this imbalance upon the therapeutic results would be wholly or partially abolished by the unequal distribution of diabetics in the two groups (Table 3) since like *Persson (1974)* we found essentially better therapeutic results in diabetics than in non-diabetics and since moreover the pulsation findings were the same in both groups of diabetics. The latter is important seeing that according to Moore et al (1972) diabetics can be considered better candidates for below knee amputation than non diabetics only if they do not have occlusion of major vessels.

Conclusion

There was no difference in the results of below knee amputation for ischaemic gangrene carried out by the transverse technique with a long posterior flap and by the the sagittal technique with two equally large medial and lateral musculo cutaneous flaps. The choice between the two methods can be based merely upon surgical skill or upon the ischaemic changes on the lower leg.

The increased use of primary below knee amputation for ischaemic gangrene in the elderly entails great advantages during convalescence if it is possible to preserve the knee. But the price of this advantage is paid for by the group of patients who later must submit to above knee amputation—in our series 24 out of 88 patients (27 per cent). Therefore there is still a need for a method of preoperative assessment of the chances of healing and thereby a guidance in the choice of amputation level (Schousbo & Zdravkovic 1974).

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FRACTURE OF THE BODY OF THE TALUS

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Fifty one patients with fracture of the body of the talus were seen at follow up examination an average of 23 months after treatment Osteonecrosis had developed in 8 out of 17 patients with displaced shearing or crush fractures of the trochlea Malunion as well as subluxation predisposed to osteoarthrosis in the subtalar and talocrural joints Thus osteoarthrosis was present in 9 out of 21 patients without malunion in 8 out of 16 patients with malunion, and in 11 out of 14 with malunion as well as subluxation Judging from the nature of the complaints the difficulties in rehabilitation and the disability assessment the prognosis was fairly grave, also after the small, usually non displaced fractures of the posterior and lateral tubercles Out of 20 patients with fractures of this type only 6 obtained almost complete relief from their symptoms only 8 could go back to their previous work on a full time basis and 11 were assessed to be 10 per cent or more disabled Fractures in the posterior and lateral tubercles must therefore be interpreted as links in more extensive injuries involving the subtalar joint and possibly the talocrural joint with associated injuries to articular cartilage joint capsules and ligaments

Key words talus fracture, osteoarthrosis, osteonecrosis, avascular necrosis

Accepted 9 ii 77

The body of the talus is subjected to tremendous strain during walking and running, in connection with the acceleration and deceleration of the body mass (Weber 1966) Only certain non physiological forces e g, pronounced caudal compression, during pronation and especially supination trauma, will injure the trochlea (Sneppen & Buhl 1974) In addition to its weightbearing function, the body of the talus is also the main component of the most important joints of the foot, the talocrural and the subtalar joints in this capacity it is of decisive importance in the hinge movements and rotation of the foot Owing to its central functions, *fractures of the talar body* often involve appreciable disability, and this is further accentuated by the special vascularisation conditions which arise in certain regional injuries, involving a marked risk of avascular necrosis of the body (Haliburton et al 1958, Larsson et al 1961, Zifko & Wellig 1969, Mulfinger & Trueta 1970, Peterson et al 1974)

A basic requirement for planning optimal treatment of fractures affecting the body of the talus is of course an adequate knowledge of the prognosis of the various types of fracture, including their relation

Table 1 Previous reports published of fracture of the body of the talus

	No of fractures without displacement	No of fractures with displacement	Total
Schrock et al (1942)	0	15	15
Kleiger (1948)	7	3	10
Coltart (1952)	15	7	22
Mindell et al (1963)	3	7	10
Pennal (1963)	3	8	11
Kenwright & Taylor (1970)	4	2	6
Present material (1977)	21	30	51

to the occurrence of osteoarthrosis and osteonecrosis Such a selective prognostic evaluation can be made only on the basis of a large material of fractures after exclusion of cases with serious complicating associated regional injuries However, fractures of the body of the talus are extremely rare, constituting only about 0 1 per cent of all fractures (Coltart 1952, Baltschew 1975) Consequently, the prognostic problems have so far been elucidated only on the basis of small series (Table 1) which do not fulfil the above-mentioned criteria

With this background, it would seem of interest to study the prognosis of the various morphological types of fracture occurring in the body of the talus, on the basis of a major material having a sufficiently long follow-up period

MATERIAL

The material is derived from the Directorate of Employment Accident Insurance Copenhagen where 218 cases concerning fractures of the talus were handled during the period 1945 1975 Of these fractures 62 affected the body of the talus This does not include cases of minor chip fractures or the osteochondritis like trochlear injuries or ligamentous avulsion fractures whose prognosis differs essentially from that of other talar fractures

In 28 cases there were associated injuries involving in 25 cases the same ankle and foot viz 21 fractures of the ankle two of the calcaneus and two of the metatarsal bones In 11 cases the associated injury was of a serious nature and may have appreciably influenced the prognosis As the present study was intended to elucidate the prognosis of talar fracture alone these 11 cases were excluded This leaves 51 fractures of the body of the talus without serious associated injuries

In all 51 cases an orthopaedic assessment was available based upon a clinical as well as a radiological examination The orthopaedic assessments X-ray films and case records were reviewed by the authors and form the basis of the present publication

In age the patients ranged from 17 to 64 years, mean age 36 The follow up period from the time of the accident until the time of the final specialist examination ranged from 9 to 76 months mean 23 months

In 32 of the 51 cases the fracture was due to falls from a height while in eight cases there had been direct trauma in five a distortion injury and in six cases traffic accidents

Figure 1 gives the morphology of the various types of fracture The compression fractures in the trochlea (A) involved only the medial or lateral part of the trochlea and exclusively the talocrural joint There were two main types of shearing fractures of the trochlea a coronal (B) and a more or less sagittal (C) one The coronal type could be mistaken for fracture of the talar neck but it was situated more posteriorly involving the trochlea and therefore could entail incongruence in the talocrural joint often blocking dorsiflexion of this joint (*Figure 2*) Both types of shearing fracture involved the talocrural as well as the subtalar joints The same applied to the minor fractures affecting the posterior (D) or lateral (E) tubercle marginal fractures not being included in the material as already mentioned Comminuted crush fractures (F) entailed fragmentation of the entire trochlea with massive incongruence in the talocrural as well as subtalar joints (Figure 3)

The relation of the fracture types to the occurrence of displacement of the fracture and to the occurrence of subluxation in the adjacent

Types of fracture







A Compression fracture

B Coronal shearing fracture

C Sagittal shearing fracture







D Fracture in the posterior tubercle

E Fracture in the lateral tubercle

F Crush fracture

Figure 1

joints is presented in Table 2 It will be seen that while a large number of the compression shearing and crush fractures were displaced and sometimes involved subluxation the majority of the fractures affecting the posterior and the lateral tubercle were not displaced

Initial treatment had been in three cases open reduction and fixation in six cases reduction and a plaster cast and in the remaining 42 cases only a plaster cast and/or non weight bearing



Figure 2 Coronal shearing fracture anteriorly in the trochlea showing severe malunion Subtalar as well as tal crural osteoarthrosis Follow-up period 20 months



Figure 3 Crush fracture with severe fragmentation of the body

Table 2 Type of fracture in relation to displacement and to subluxation in the subtalar and or talocrural joints

Type of fracture	Fracture without displacement	Fracture with displacement	Fracture with displacement and subluxation	Total
Compression	0	10	0	10
Shearing	4	3	10	17
Posterior tubercle	10	1	0	11
Lateral tubercle	7	1	1	9
Crush	0	1	3	4
Total	21	16	14	51

RESULTS

The most important complications, from the prognostic point of view, were avascular necrosis, malunion, and osteoarthrosis in the talocrural and/or subtalar joint

Avascular necrosis In eight cases there was marked condensation of the trochlea In seven of them, moreover, the trochlea was deformed by collapse, in two of the cases this deformity was very pronounced (Figure 4) Out of the eight cases of avascular necrosis, five occurred among the 13 displaced shearing fractures and three among the four crush fractures

Malunion Thirty fractures of the talar body were primarily displaced—16 slightly, while 14 showed marked malalignment with a break of 3 mm or more in the joint surface or with crushing and deformity of major parts of the body In 9 of these 14 cases, an attempt at reduction had been made initially, but the displacement could be reduced to mild in only four of the cases This left 10 cases with severe (Figure 2) and 20 with slight malunion

Osteoarthrosis Twenty-eight patients developed osteoarthrosis (Tables 3 and 4) This complication occurred with approximately the same frequency in all types of fracture except for those of the lateral tubercle which were followed by osteoarthrosis in only one case out of nine It is worthy of particular note that among the 11 cases having fracture of the posterior tubercle eight were complicated by osteoarthrosis Relating the occurrence of osteoarthrosis to malunion and to subluxation shows, as might be expected, that both predispose to osteoarthrosis (Table 4)

Other complications Bony ankylosis in the subtalar joint occurred during the healing of one crush fracture complicated by osteonecrosis There were two cases of skin necrosis and infection, one involving osteitis and long-lasting fistula



Figure 4 Coronal shearing fracture anteriorly in the body complicated by osteonecrosis and severe deformity of the trochlea Follow-up period 14 months

Table 3 Occurrence of talocrural and subtalar osteoarthrosis in relation to type of fracture

ype of acture	Talocrural osteoarthrosis	Subtalar osteoarthrosis	Talocrural and subtalar osteoarthrosis	No osteoarthrosis	Total
ompress on	5	0	0	5	10
hearing	3	1	7	6	17
osterior tubercle	2	5	1	3	11
ateral tubercle	0	1	0	8	9
rush	1	0	2	1	4
otal	11	7	10	23	51

Table 4 Occurrence of osteoarthrosis in relation to malunion or union in subluxation in the talocrural and/or subtalar joint

	Osteoarthrosis	No osteoarthrosis	Total
Fracture un ted without displacement	9	12	21
racture un ted with displacement	8	8	16
racture un ted with d splacement and subluxation	11	3	14
Total	28	23	51

Table 5 Subject ve results

Type of fracture	Complaints			Total
	Minor or none at all	Moderate	Severe	
ompress on	5	1	4	10
hearing	1	6	10	17
osterior tubercle	3	5	3	11
ateral tubercle	3	3	3	9
rush	0	0	4	4
otal	12	15	24	51

ion In three non union resulted from minor mainly intra articular bone fragments

Secondary treatment

Because of secondary osteoarthrosis and pain on weightbearing fusion was performed in four cases subtalar in three and talocrural in one In three cases a non united partially free bone fragment was removed from the talocrural joint Nine patients were later fitted with orthopaedic footwear

Subjective result

At the final follow up examination 39 patients still had complaints mostly in the form of pain in the ankle region and hindfoot on weightbearing From Table 5 it is apparent that these complaints manifested themselves not only after major fractures but to a large extent

Table 6 Influence of talar injury on occupational capacity

Type of fracture	Back to previous work	Obtained lighter work	Not working	Total
Compression	5	2	3	10
Shearing	6	6	5	17
Posterior tubercle	4	5	2	11
Lateral tubercle	4	3	2	9
Crush	0	4	0	4
Total	19	20	12	51

Table 7 Disablement assessment

Type of fracture	Disablement percentage				Total
	0	5–8	10–12	> 12	
Compression	2	5	1	2	10
Shearing	0	4	2	11	17
Posterior tubercle	0	5	6	0	11
Lateral tubercle	1	3	5	0	9
Crush	0	0	0	4	4
Total	3	17	14	17	51

also after the minor, mainly non-displaced fractures of the posterior and lateral tubercles

Rehabilitation

The occupational situation of 39 patients was permanently altered by the talar injury, and as is shown in Table 6 there were considerable rehabilitation problems after fractures of the posterior and the lateral tubercles Thus, out of 20 patients with injuries of this type, only eight were able to resume full employment in their previous occupation

Disability assessment

One expression of the prognosis is the disablement percentage which is fixed in each case by the Directorate of Employment Accident Insurance and which forms the basis of the compensation From Table 7, it can be seen that in the various types of fracture the disablement percentage agreed with the subjective result and with the rehabilitation difficulties, as shown in Tables 5 and 6 respectively

DISCUSSION

It is generally known that severe fractures of the body of the talus, including displaced shearing fractures and crush fractures, have a serious prognosis Mindell et al (1963) reported good results in only two out of seven displaced fractures of the talar body, three of which developed osteonecrosis Coltart (1952) found osteonecrosis in five out of six displaced fractures of the body and reported a high incidence of post-traumatic osteoarthrosis, especially in the subtalar joint However, the results of the displaced intra articular fractures appear to depend to some extent upon what degree of reduc

-tion is obtained (Coltart 1952, McKeever 1963, Kenwright & Taylor 1970)

As regards these severe fractures, the present study confirmed the previous results We also found a high frequency of osteonecrosis, a high incidence of osteoarthrosis which definitely seems to depend upon malunion and subluxation (Tables 3 and 4), and a late result characterised by appreciable subjective complaints (Table 5) and rehabilitation difficulties (Tables 6 and 7) The treatment of these fractures should be according to the current lines (Watson Jones 1962), but with great emphasis on an exact reduction and a stable fixation whenever possible, a procedure which often necessitates operation Most authors have indicated a good prognosis in minor, mainly non-displaced fractures (Kleiger 1948, Mindell et al 1963, Kenwright & Taylor 1970) Only Coltart (1952) mentioned an appreciable frequency of late subtalar osteoarthrosis following non-displaced fractures of the talus The present study revealed a far more serious prognosis for the small, mainly non-displaced fractures of the posterior and lateral tubercles than has previously been assumed This more serious prognosis was manifest, as regards fractures of the posterior tubercle, in a very high incidence of osteoarthrosis (Table 3), and in the case of both types of fracture, in severe complaints (Table 5), rehabilitation problems (Table 6), and a fairly high disability assessment percentage (Table 7)

In our opinion the majority of these fractures, fairly negligible *per se*, form a link in more extensive regional injuries involving the talocrural and especially the subtalar joint Thus, at the time of the accident there has been subluxation, and the consequent articular injury bears the main responsibility for the grave long term prognosis We feel, therefore, that in treating fractures of the posterior and lateral tubercles it is important to aim at rapid normalisation of the function in the talocrural and subtalar joints This is best obtained by fairly brief immobilisation which affords a possibility for the healing of the joint capsule and ligamentous structures Thereafter, energetic active training of foot movement should be instituted As these fractures invariably involve a weightbearing joint surface, the patients should not be allowed to bear weight on the foot until solid union of the fractures has been obtained

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SUPINATION DEFORMITY OF THE FOREFOOT

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and the Orthopaedic Hospital of the Invalid Foundation Helsinki Finland

Supination deformity of the forefoot is rare Observations of eleven cases and the production of the deformity in rabbits suggest that loss of function of the peroneus longus muscle in combination with the effect of a strong tibialis anterior muscle is decisive for the appearance of the deformity Primary conditions causing deformity were spina bifida talipes equinovarus poliomyelitis trauma and muscular dystrophy Treatment by wedge resection of the first cuneiform and the first metatarsal bones and transfer of the tibialis anterior tendon was successful Operations for supination deformity were carried out in nine cases

Key words foot deformity hallux equinus dorsal bunion

Accepted 11 i 77

In 1957, one of the authors (A L) encountered for the first time a patient with a marked supination deformity of the forefoot, the hindfoot being in a neutral position (Case 7, Table 1) Since then the authors have seen 10 additional cases of this very typical but fairly rare deformity A thorough search of the literature revealed that only five authors have given descriptions of it Duchenne published a drawing of it in 1867 (Figure 7) He called it talipes planus varus and stated that it was a sequel to paralysis of the triceps surae the peroneus longus and the flexors, in combination with an intact tibialis anterior muscle In 1925, Hohmann described the deformity as isolated supination contracture of the forefoot He wrote "Hitherto I don't know about any description of this highly characteristic deformity "

In 1940 Lapidus described the deformity under the name "Dorsal Bunion and recommended an operation which had been carried out in six patients with encouraging results Lapidus wrote· "With the exception of Hohmann's classic book 'Fuss und Bein' the author has been unable to find any satisfactory description of it in the literature " Lapidus stressed that the dorsiflexed position of the first metatarsal bone plays an important part in the deformity and its correction

In 1943 Hammond reported 42 examples of "elevation of the first metatarsal bone with hallux equinus" He wrote "There is no doubt that this condition has been recognized by many observers but specific reference to it is rare in the available literature" In 1966, Palazzi et al, reporting the results of 1518 tendon transfers in paralytic feet, mentioned supination deformity of the forefoot as a complication in 18 cases after transfer of the peroneus longus tendon

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unation deformity of the forefoot

ate of birth	Right or left foot *Age at operation for* supination deformity (years)	Date of follow up	*Figures* Remarks
14th 1952	R (13)	Sept 27th 1973	Figure 1 A–C
r 9th 1945	R (21)	Oct 5th 1973	Figure 2 A–G
rch 8th 1958	*I (8)*	*Oct 9th 1973*	*Figure 3 A–C*
t 21st 1958	R (8)	Sept 17th 1973	
or 29th 1957	R (10)	Sept 27th 1973	Figure 4 A–C
ec 1st 1951	R and L (16)	Oct 29th 1973	Figure 5 A B
ug 25th 1953	R and I Not operated	Oct 9th 1972	
ct 9th 1947	I Not operated	Sept 27th 1973	Figure 6
Ias 25th 1957	R (16)	May 7th 1975	*Figure 8 A–C*
July 22nd 1958	R (16)	Oct 8th 1975	
Dec 29th 1964	R (9)	Oct 8th 1975	Only transfer of tib ant tendon

Table 1. Details of the 11 patients r

Case no.	Sex	Primary condition causing foot deformity	Operations and history before developm of supination deformity of the forefoot
1	M	Spina bifida. Sacral meningomyelocele. Weakness of triceps surae especially on the right side	Right peroneal tendons and tibialis poste tendon transferred to tendo calcaneus in 1
2	M	Poliomyelitis. Muscle weakness in right leg. Calcaneo valgus deformity of right foot	Right peroneal tendons transferred to tendo calcaneus in 1952
3	M	Congenital equinovarus deformity of left foot. Congenital ring constriction of left leg	Plastic operations on the leg for ring constriction in 1959–1960. Tenotomy of te calcaneus in 1960
4	M	Poliomyelitis in 1960. Palsy of right leg. Peroneus longus and long flexors and long extensors of the toes completely paralysed	Extra articular subtalar arthrodesis *ad modum* Grice, transfer of the peroneus brevis to tendo calcaneus and abbreviatio the extensor hallucis longus tendon in 19
5	F	Congenital equinovarus deformity of both feet	Tenotomy of the tendo calcaneus, correct under general anaesthesia, plaster treatm and derotation osteotomy of both legs in 1959. Lengthening of right tendo calcaneus in 1962. Operative soft tissue release and correction of right foot in 1963
6	F	Congenital defect of sacrum with muscle weakness in both legs. Vertical talus deformity and supination deformity of the forefoot on both sides	Not operated on before correction of supination deformity of the feet. Weakness of all muscles of the legs, flexor hallucis brevis and extensor digitorum longus completely paralysed
7	M	Congenital muscular dystrophy. Weakness of peroneal muscles on both sides. Marked supination deformity of left forefoot, slight supination deformity of right forefoot	Conservative treatment of feet in plaster in 1957. Triple arthrodesis of left foot with poor result in 1972
8	M	Cutting trauma from window glass to the upper lateral part of the left leg in 1955	After trauma progressive supination deformity of left forefoot. Operations on t e tendons 1965 and 1967 without correction of forefoot deformity
9	M	Congenital equinovarus deformity of the right foot	Operative soft tissue release, lengthening of the tibialis posterior and flexor digitorum communis tendons and radical release of ligaments on the plantar side of the foot in 1962. After operation slowly progressing supination deformity of the forefoot. Calcaneo navicular fusion present
10	M	Spina bifida. Multiple anomalies of the lumbar spine	No operations for foot deformity. Extirpat n of lumbar hemivertebra with regain of trunk balance in 1968. No change in muscle power after operation
11	F	Semimalignant haemangioma in the peroneal region of the right leg	Resection of fibula, peroneal muscles and long extensor muscles of the leg in 1971

ation deformity of the forefoot

of birth	Right or left foot Age at operation for supination deformity (years)	Date of follow-up	Figures Remarks
14th 1952	R (13)	Sept 27th 1973	Figure 1 A–C
9th 1945	R (21)	Oct 5th 1973	Figure 2 A–G
ch 8th 1958	L (8)	Oct 9th 1973	Figure 3 A–C
21st 1958	R (8)	Sept 17th 1973	
r 29th 1957	R (10)	Sept 27th 1973	Figure 4 A–C
c 1st 1951	R and L (16)	Oct. 29th 1973	Figure 5 A–B
g 25th 1953	R and L Not operated	Oct 9th 1972	
ct 9th 1947	L Not operated	Sept 27th 1973	Figure 6
lay 25th 1957	R (1[illegible])	May 7th 1975	Figure 8 A–C
July 22nd 1958	R (16)	Oct 8th 1975	
Dec 29th 1964	R (9)	Oct 8th 1975	Only transfer of tib ant tendon

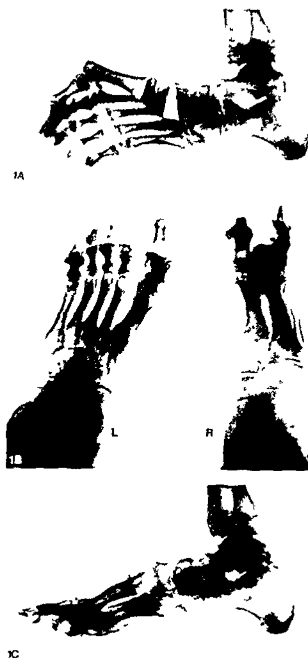


Figure 1 Case 1 Spina bifida A Radiograph of right foot before operation at the age of 13 years B Radiograph of both feet before operation C Radiograph of right foot 2½ months after operation Resected bone areas seen in A

MATERIAL

The eleven patients with typical supination deformity of the forefoot seen by the authors are listed in Table 1 From this Table it appears that several different affections and therapeutic procedures in varying combinations have provoked the deformity

In three cases the primary condition causing foot deformity was spina bifida (Cases 1 6 and 10, Figures 1 and 5) In two of these the supination deformity of the forefoot developed before any operation had been performed on the foot and in one after tendon transfer In three cases the primary condition was congenital talipes equinovarus (Cases 3 5 and 9 Figures 3, 4 and 8) Radical soft tissue release with possible damage to the tendon of the peroneus longus muscle, had been performed in two of these cases and in one there was a congenital ring constriction of the leg with absence of function of the peroneal muscles In two cases the deformity developed after poliomyelitis (Cases 2 and 4, Figure 2) In one of these the peroneus longus muscle was paralysed and in the other the peroneus longus tendon had been transferred to the tendo calcaneus

In two cases the deformity developed after the function of the peroneus longus muscle had been lost in connection with trauma (Cases 8 and 11 Figure 6) In two of the cases the supination deformity of the forefoot was combined with calcaneus or calcaneovalgus deformity of the hindfoot (Cases 1 and 2, Figures 1 and 2) and in two with a vertical talus deformity (Cases 6 and 10, Figure 5) In one case the cause was muscular dystrophy (Case 7)

OPERATION

The main cause of the supination deformity of the forefoot seemed to be the elevation of the first tarsal and metatarsal ray caused by muscle imbalance during the growth period Thus plantar wedge resection of the first cuneiform bone and of the base of the first metatarsal bone in order to bring the head of the first metatarsal bone into a normal position, seemed to be a logical procedure for correction of the deformity A transfer of the tibialis anterior tendon to the middle of the dorsum of the foot also seemed necessary to prevent recurrence

The operation described here was planned for the case seen in 1965 (Case 1, Table 1) At that time the authors were not aware of the somewhat different method described by Lapidus As the result in the first case was satisfactory, the operation was performed on nine feet with some individual variations The age at operation varied between 8 and 21 years

Operative technique

A longitudinal incision is made on the medial plantar aspect of the foot in order to expose the medial and plantar surfaces of the first cunei-

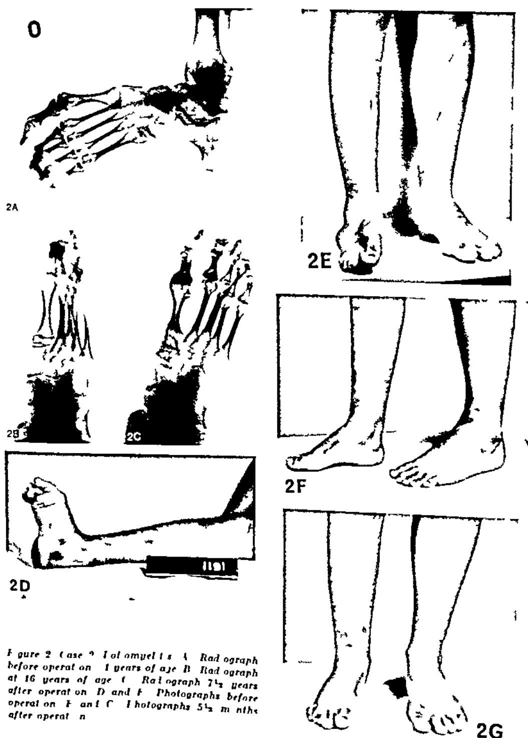


Figure 2 Case 9 Poliomyelitis A Radiograph before operation [illegible] years of age B Radiograph at 16 years of age C Radiograph 7½ years after operation D and E Photographs before operation F and G Photographs 5½ months after operation

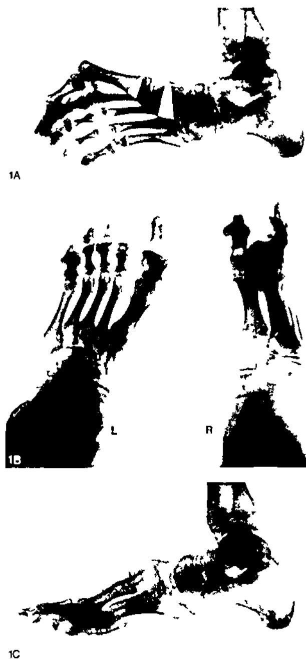


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Operative technique

A longitudinal incision is made on the medio plantar aspect of the foot in order to expose the medial and plantar surfaces of the first cunei



4A





Figure 4 Case 5 Congenital talipes equinovarus A Photograph at the age of 3½ years before any treatment B Photograph at the age of 10 before operation for supination deformity of the right forefoot C Photograph aged 16 years 6 years after the operation

ducted through the tendon sheath of the long extensor of the toes to the dorsum of the foot. An incision is made over the medial edge of the cuboid bone. The end of the tibialis anterior





Figure 5 Case 6 Spina bifida A Radiograph of right foot at 16 years of age, before the operation B Radiograph of right foot 5¾ years after operation

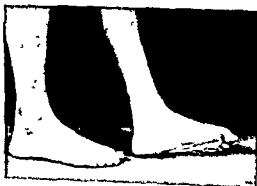


Figure 6 Case 8 Deformity after traumatic rupture of peroneal tendons

tendon is drawn to the dorsum of the foot and implanted by means of an intraosseal suture into the medial part of the cuboid bone. A plaster cast is applied from the toes to the knee. The foot is kept in plaster for 8 weeks.

RESULTS

The results of the operation are evident from the illustrations. The feet are, of course, by *no means* normal but the operation corrected the supination de-





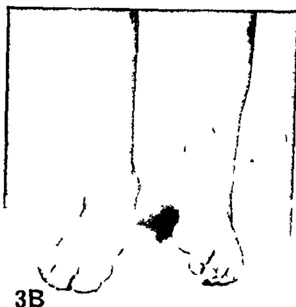


Figure 3. Case 3. Congenital talipes equinovarus. A. Photograph at the age of 1 year. B. Photograph at age 8½ years of age before the operation. C. Photograph 7½ years after operation.

form bone and the base of the first metatarsal bone. The tendon of the tibialis anterior muscle is dissected from its insertion into the bones mentioned. A wedge of bone with its base on the plantar side is resected with a chisel from the first cuneiform bone without opening the adjacent joints (see Figure 1 A). In some cases the deformity is corrected when the resection surfaces of the first cuneiform bone are brought together and fixed with a staple or a strong suture (Cases 3 and 4). When the correction is not sufficient another wedge is chiselled out from the base of the first metatarsal bone distal to the epiphyseal plate. In six feet correction of supination deformity of the forefoot was satisfactory after wedge resection of the two bones (Cases 1, 2, 5, 6 right and left and 10). In one foot (Case 9, Figure 8) there was fusion of the calcaneus and the navicular bone. The supination deformity could not be corrected before resection of the calcaneo-navicular bone bridge and triple arthrodesis had been performed in addition to wedge resection of the first cuneiform and the first metatarsal bones.

When the deformity has been corrected by wedge resection of the bones and the resection surfaces have been fixed against each other with staples or strong sutures, a longitudinal incision is made in front of the distal part of the leg in order to expose the proximal part of the tibialis anterior tendon. The tendon is drawn from its insertion into the wound in the leg and con-

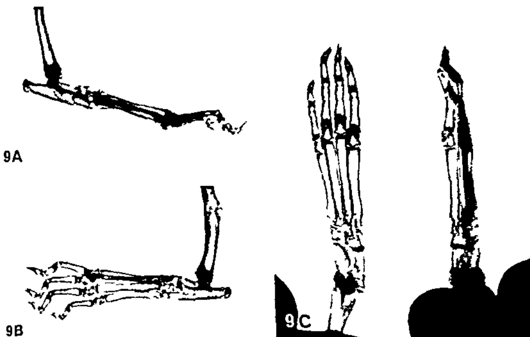


Figure 9 Rabbit A Side view radiograph of normal foot of growing animal B Side view radiograph of foot some weeks after section of peroneal muscles and tenodesis of Achilles tendon Compare with Figures 1 A and 5 A C Dorso-plantar radiographs corresponding to A (normal) and B (supination deformity of the forefoot) Compare with Figures 1 B and 2 B

bits were less than 3 weeks old when operated on, the developing deformity was more severe than if they were 4 to 6 weeks old Figure 9 A C shows the typical deformity produced in the rabbit

The experiments support the idea that loss of function of the peroneus longus muscle in combination with the effect of a strong tibialis anterior muscle is decisive for the appearance of supination deformity of the forefoot

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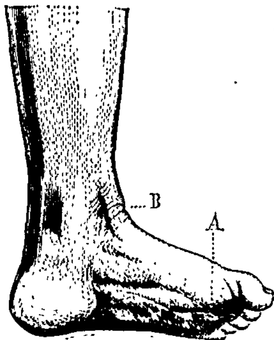


Figure 7. Picture published by Duchenne in 1867 "Pied plat varus" from palsy of triceps surae, peroneus longus and toe flexor muscles.

formity in all nine feet operated on. In no case was there any pain or functional disturbance, which could be ascribed to the operation, when follow-up examination was done.

SUPINATION DEFORMITY OF THE FOREFOOT PRODUCED EXPERIMENTALLY IN THE RABBIT

In connection with a study of the effect of tenotomies on the feet of growing rabbits, one of the authors (V.R.) found that isolated supination deformity of the forefoot regularly appeared after certain procedures. This deformity was seen in 21 rabbits and the common factors in all these experiments were that the peroneal tendons had been cut and the tibialis anterior had been left intact. If the rab-





8B



8C

Figure 8 Case 9. Talipes equinovarus A. Photograph of right foot before operation at the age of 16 B. Radiograph of right foot before operation. C: Radiograph of right foot 6 months after operation

THE RESULTS OF 41 BELOW KNEE AMPUTATIONS (SAGITTAL TECHNIQUE) IN RELATION TO LOCAL SKIN PERFUSION PRESSURE

Per Lund & Philip Sager

The material consisted of 68 per cent males and 32 per cent females Forty four per cent were diabetics The average age was 71 7 years (range 45–88 years) Preoperatively the local arterial skin perfusion pressure in the area of amputation (external counterpressure isotope technique) was measured in all patients

There were 10 (24 4 per cent) femoral re amputations Six out of 16 patients (37 5 per cent) with preoperative skin blood pressures below 40 mmHg underwent re-amputation and 4 out of 25 (16 0 per cent) with pressure above 40 mmHg Re amputation was more common in diabetics (33 3 per cent) than in non-diabetics (17 4 per cent) In all cases of re amputation there was concomitant infection leading to re amputations even in patients with a good local blood supply

FRACTURA TALI

J F Lorentzen & O Krogsoe

A total of 123 patients with fracture of the neck of the talus were followed up with a mean observation time of 22 months The distribution of the 123 fractures was as follows 54 fractures of the neck without dislocation 53 fractures with dislocation and subtalar luxation or sub luxation and 16 fractures with dislocation and simultaneous luxation of the trochlea in the ankle joint as well as in the subtalar joint The results were 26 patients (21 per cent) developed avascular necrosis of the trochlea resulting in severe osteoarthrotic changes 38 patients (31 per cent) developed talocrural arthrosis and 58 (47 per cent) subtalar arthrosis 87 (71 per cent) expressed moderate or pronounced complaints For 74 patients 60 per cent) the fracture meant a change of employment or disability

SUBTALAR DISLOCATION

Steen Bach Christensen

Thirty three subtalar dislocations were reported An account was given of the typical fractures following the lesion with special reference to the mechanism and consequences of fracture of the processus posterior tali

The long term prognosis in this material seems to be worse than is generally assumed to be the case Two patients had avascular necrosis followed by panarthrosis and a further 18 patients had radiological arthrosis in the subtalar joints Clinically 23 patients had pain during strenuous activities and 15 patients had a limp

The incidence of arthrosis in the dislocations without fractures is surprisingly high and a comparison of the immobilisation periods suggests that early mobilisation will reduce the risk of arthrosis

THE HEALING OF BELOW KNEE AMPUTATIONS IN RELATION TO PERFUSION PRESSURE OF THE SKIN

E Hammersgaard & K Baadsgaard

Sixty nine below knee amputations utilizing a long posterior musculocutaneous flap were performed on 67 patients with occlusive arterial disease

Nine patients had skin necrosis and deep in fection Six had to be re amputated above the knee The frequency of re amputations was thus 9 per cent the mortality was 15 per cent

In 56 cases skin perfusion pressure 10 cm below the knee was measured preoperatively Among 50 cases with a pressure > 30 mmHg only one had to be re amputated Of the 6 patients with a pressure < 20 mmHg two had to be re am putated

BLADDER FUNCTION AFTER HEMIPELVECTOMY

T Gerstenberg J Boss Nielsen M Fykkegaard Nielsen & L Palm

A urological follow up of 7 patients was per formed 5–90 months after hemipelvectomy The follow up included cystometry urodynamic in vestigations IV pyelogram micturition-cysto

metric and urodynamic investigation showed no neurogenic bladder dysfunction It is concluded that a possible unilateral denervation of the bladder does not result in disturbances of blad der function

LATE ULNAR PALSY ETIOLOGY PATHOGENESIS AND MICROSURGICAL TREATMENT

Ole Osgaard

Late ulnar palsy which has been recognized since the beginning of the 19th century can be roughly divided into two etiological groups one group having sustained an adequate trauma of the elbow region or a deformation of the elbow and an "idiopathic" group In both groups a connective tissue mass is found in the nerve constricting the nerve fascicles, and by a new microsurgical method this tissue can be removed

Acta orthop scand 48, 334–337, 1977

PROCEEDINGS OF THE DANISH ORTHOPAEDIC SOCIETY

April 30, May 1, 1976

FRACTURE OF THE TALUS A STUDY OF ITS GENESIS AND MORPHOLOGY

Otto Sneppen

In a material of 7192 ankle fractures and 218 talar fractures and/or subtalar dislocations, there were 59 cases of combined ankle and talar fracture On the basis of a classification of the ankle fractures, it could be concluded that the position of the foot at the moment of injury is of decisive importance for the frequency of occurrence of talar fractures and dislocations Supination in particular predisposed to fracture of the neck and trochlea of the talus as well as to subtalar dislocation

SPINAL FUSION

F Buus & S Pilgaard

A follow up of 57 patients who had spinal fusion performed during the period 1949 to 1962 is presented The diagnoses were poliomyelitis, 37 cases, congenital scoliosis, 8 cases, idiopathic scoliosis, 10 cases, v Recklinghausen s disease 1 case and muscular dystrophy, 1 case

In 25 cases the major curve was between 40 and 69°, in 32 cases 70 to 100° The curves were corrected in a Risser jacket and fused through a window in the cast The small joints were not opened and bank bone was used The patients were kept recumbent in casts for 10–12 months postoperatively

The loss of correction found was less than 30 per cent in 12 cases from 30–60 per cent in 27 cases and from 60–100 per cent in 10 cases Six patients had, postoperatively, a greater curve than before treatment In spite of the great loss of correction only 12 patients complained of back pain, 38 were working and seven were receiving disability pension The operative procedure has since been altered

A PHOTOELASTIC STUDY OF HIP NAIL PLATES

J Steen Jensen

Photoelastic studies of an acrylic model of the upper femur were demonstrated The authors standard model had a femoral inclination of 5° The resultant hip pressure was found to act at 6° inclination and the abductor muscle pull at 20° inclination with the vertical The abductor pull was found to be 0 57 times the hip pressure

Photoelastic studies of Jewett nail plates with 125°–160° angulation were presented

In osteosynthesis the largest possible nail plate angle is recommended, in order to reduce the strain on the nail plate

A PHOTOELASTIC STUDY OF OSTEOSYNTHESIS OF UNSTABLE TROCHANTERIC FRACTURES USING HIP NAIL PLATES WITH DIFFERENT ANGLES

J Steen Jensen

Acrylic models of unstable trochanteric fractures osteosynthesized with Jewett nail plates at angles of 125°, 140° and 160° were demonstrated Photoelastic studies confirm that the largest possible nail plate angle should be used to reduce the strain on the nail plate junction

RECURRENT DISLOCATION OF THE ELBOW

Torben Weeke

Three cases of recurrent dislocation of the elbow encountered since 1968 are reported They were treated at the Orthopaedic Hospital Dept 2 Copenhagen An anamnestic survey of the cases is given They were operated *ad modum* Reichenheim & King all with good result A survey of the 56 cases contained in 28 reports in the literature since 1871 is given

Because of Reichenheim's rather complicated exposure of the elbow and problems with scarring on the front of the joint we recommend the method of Osborne & Cotterill which has been reported to have been successful in eight cases

O ... KNEE ... IN ...

PRESSURE
Per Lund & Philip Sager

The material consisted of 68 per cent males ...

skin perfusion pressure in the area of amputation (external counterpressure isotope technique) was measured in all patients

There were 10 (24.4 per cent) femoral re-amputations Six out of 16 patients (37.5 per cent) with preoperative skin blood pressures below 40 mmHg underwent re-amputation and 4 out of 25 (16.0 per cent) with pressure above 40 mmHg Re-amputation was more common in diabetics (33.3 per cent) than in non-diabetics (17.4 per cent) In all cases of re-amputation there was concomitant infection leading to re-amputations even in patients with a good local blood supply

FRACTURA TALI
J F Lorentzen & O Krogsøe

A total of 123 patients with fracture of the neck of the talus were followed up with a mean observation time of ?? months The distribution of the 123 fractures was as follows 54 fractures of the neck without dislocation 53 fractures with dislocation and subtalar luxation or subluxation and 16 fractures with dislocation and simultaneous luxation of the trochlea in the ankle joint as well as in the subtalar joint. The results were ?6 patients (21 per cent) developed avascular necrosis of the trochlea resulting in ...

... expressed moderate or pronounced complaints. For 74 patients (60 per cent) the fracture meant a change of employment or disability

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A urological follow up of 7 patients was performed 5–90 months after hemipelvectomy The follow up included cystometry urodynamic investigations IV pyelogram micturition cystourethrography and cystoscopy

All patients had at the time of the follow up clinically normal micturition and the cystometric and urodynamic investigation showed no neurogenic bladder dysfunction It is concluded that a possible unilateral denervation of the bladder does not result in disturbances of bladder function

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by microdissection of the fascicles In most cases clinical and neurophysiological recovery is achieved 6 9 months after the operation

OCCULT PATELLA LUXATION
Klaus Jacobsen & Peter Mel

In 10 patients admitted with haemarthrosis of the knee denying earlier or recent patellar dis location we found during operation and with radiographs the pathognomonic signs of this condition An immediate spontaneous reduction had taken place

THE PROGNOSIS OF NERVE LESION IN THE VOLAR CARPAL REGION
Henning Overgaard Nielsen & Jorgen Lauritzen

Over a 7 year period 19 lesions of the median nerve 5 of the ulnar nerve and 3 of both nerves were repaired Twelve were treated by primary atraumatic suture and the remaining 15 by secondary repair but nerve grafting was not used There were 16 cases of lesion of the finger flexors Twenty three patients were reviewed All had regained protective sensation of touch and function of the sweat glands but only 9 could discriminate below 2 mm and had regained some stereognosis All repaired tendons were functioning perfectly All the children had re covery completely Of the 18 adults 11 had re turned to their former job while 3 now had another full time job

SHOULDER ARTHROGRAPHY AS A METHOD FOR DIAGNOSIS OF ROTATOR CUFF LESIONS
Erik Martin Jensen

The diagnosis of traumatic as well as degen erative shoulder pain can be difficult Shoulder arthrography which can be performed in the ambulatory patient without risk or appreciable discomfort is an important diagnostic tool

Out of 175 shoulder arthrographies only eight resulted in mild discomfort

Shoulder arthrography in a group of 18 pa tients with long term loss of mobility after shoulder injury showed rotator cuff lesion in 16 cases The patients had been treated initially in an emergency room without the diagnosis having been made clinically The prognosis was poor as eight patients never attained active mobility and three patients only attained active mobility up to 90°

The importance of an early diagnosis of rotator cuff lesions must be emphasized even when operative treatment is not being con sidered

A FOLLOW UP STUDY OF TIBIAL SHAFT FRACTURES COMPARISON OF CONSERVATIVE TREATMENT AND OSTEOSYNTHESIS WITH CONVENTIONAL PLATES AND ASIF PLATES
J Steen Jensen F Wang Hansen & J Johansen

A total of 238 tibial shaft fractures were reviewed after a mean observation time of 3 5 years 102 fractures were treated conservatively Osteosynthesis was performed using conven tional plates in 41 cases ASIF plates in 64 and other methods were used in 31 cases

At the follow up malpositioning was en countered in 21 per cent of the conservatively treated and in 10 per cent with conventional plates

In closed fractures there was non union in 6 per cent of the conservatively treated and in 8 per cent of those treated with conventional plates There were 4 per cent with deep infection with conventional plates as against 5 per cent with ASIF plates

In compound fractures conservative treatment led to 21 per cent with non union and 3 per cent with deep infection With ASIF plates there were 11 per cent with deep infection and with con ventional plates 24 per cent with non union and 12 per cent with deep infection

ASIF plate osteosynthesis was found to be justified in the treatment of tibial shaft frac tures

SCOLIOSIS TREATED WITH HARRINGTON INSTRUMENTATION
F Harlyck & F Thomasen

Since 1972 at the Orthopaedic Hospital in Aarhus 37 cases of scoliosis have been treated with posterior fusion and internal fixation using Harrington instrumentation The average pre operative curve was 73° The results in 25 pa tients with an observation period of more than 1 year show an average initial postoperative correction of 45 per cent of the preoperative angle Walking with a Milwaukee brace is started after 6 weeks and the brace is used for 1 year after the operation

During the first year the loss of correction varied from 0 to 23° so that the final average correction was 33 per cent of the preoperative angle There were no cases of pseudarthrosis

ATLANTO AXIAL INTERLAMINAR FUSION
K Harry Sorensen & Jak I Husby

Thirty six patients were treated with atlanto axial interlaminar fusion utilizing a special technique and team work between neurosurgeon and orthopaedic surgeon Two bone grafts from

the iliac crest with grooves for the two laminae were fixed with steel wires

Twenty-one patients had a fracture of the dens axis (5 pseudoarthrosis) and 10 rheumatoid arthritis (7 horizontal and 5 vertical dislocation) 8 had medullary symptoms Five had other lesions

All fusions were solid at follow up at least 1 year after the operation Great relief of symptoms was achieved with a minimum of restriction of movement of the cervical spine

ANTERIOR LUMBAR INTRACORPOREAL FUSION

K Harry Sorensen

Ninety eight patients had fusion performed (extraperitoneal technique) Indications were incapacitating low back pain caused by degeneration of the 4th/5th lumbar discs or spondylolisthesis 135 discs were degenerated 114 were fused There were no complications in 75 per cent However 11 had thrombophlebitis 2 fatal pulmonary embolism 4 slight infarctions and 3 severe atelectasis

At follow up 3–8 years later, the fusions were solid in 91 per cent and after re operation in 94 per cent Healing was not achieved in 21 per cent of the patients with spondylolisthesis 73 per cent felt better or cured 31 patients had constant pain (21 somatic explanation) 60 per cent of patients operated upon after the age of 45 received disablement pension

MODULAR KNEE PROSTHESIS

N O Christensen

In contrast to the hinge type of knee prosthesis (Waldius Guepar etc) the modular type of prosthesis (Marmor St Georg) uses minimal amounts of foreign material and allows for only one compartment of the joint to be replaced as this is generally sufficient Severe instability and angulation can be treated effectively in this way The patients are walking after 1 2 days In rheumatoid arthritis both compartments must be replaced in most cases

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PROCEEDINGS OF THE FINNISH ORTHOPAEDIC ASSOCIATION

25th Anniversary Meeting

Helsinki, Finland, 13 November 1976

EDITOR A ALHO

STUDIES OF POSTOPERATIVE METABOLISM IN THE KNEE USING INTRA-ARTICULAR FLUID ANALYSIS

S Finola & J Nunikoski
Department of Surgery
Turku University Central Hospital

Under normal conditions the synovial membrane is well vascularized and acts as a dialyzing membrane between the joint cavity and the circulation In arthritis the tissue environment becomes more ischemic and this may result in chondrocyte damage and even death at the articular surface The response of synovial tissue metabolism to surgical trauma was investigated using postoperative synovial fluid analysis after two types of operation, medial meniscectomy and synovectomy Analyses were also performed in nonoperated patients with traumatic effusion or chronic synovitis of the knee It was found that the knee joint metabolism in chronic synovitis *is shifted towards anaerobic glycolysis in* both operated and nonoperated patients whereas meniscectomized and traumatic knees are considerably more capable of maintaining oxidative metabolism

BASAL OSTEOTOMY OF THE FIRST METATARSAL BONE IN HALLUS VALGUS EXPERIENCES WITH THE USE OF AO PLATE

V Avikainen T Tervo, H Vaherto & P Rokkanen
Orthopaedic Department
Central Hospital of Central Finland
Jyvaskyla

For young patients osteotomy operations are frequently considered together with excision of the exostosis A less favoured osteotomy method has been the basal laterally based wedge osteotomy, which was first introduced by Loison (1901) and Balacescu (1903) However, this operation is able to correct the metatarsus primus varus quite efficiently To stabilize the correction we have added a small AO plate for fixation In addition plaster of Paris has been applied for 6 weeks In 33 patients, 46 feet were operated on There were 31 women and 2 men Only two of the patients were over 50 years of age Pain was the most frequent indication A follow up was made an average of 1 5 years post operatively Subjective results were good in 35 *cases, fair in 9 and poor in one* Objectively the results were good in 36 cases and fair in 9 The follow up of one patient is not yet completed The mean period off work was 7 weeks Metatarsus varus angle was reduced from 14 8° to 9 3° and halux valgus angle from 33 2° to 17 7° Mt I–II distance was reduced from 13 7 mm *to* 10 2 mm One wound infection was registered and one patient had postoperative oedema A good functional and cosmetic result was achieved in most of the cases

UPPER EXTREMITY DEFORMITIES COMBINED WITH ORO FACIAL CLEFTS

Vappu Uuspaa
Finnish Red Cross Cleft Centre

The series consists of 89 cases *with upper* extremity deformities among the 3 225 cleft patients born during the period 1950–75 and treated at our centre (see Table) Two thirds of the patients had a cleft palate, including half of the males and nearly all of the females The percentage of upper extremity deformities in *the* different types of oro facial clefts was as follows cleft lip 0 8, cleft lip and palate 1 6 (cleft of the secondary palate 3 5), branchial arch syndrome (lateral cleft) 6 2, the total average was 2 8 per cent One third of the patients were dwarfs most of them diastrophic dwarfs Only 11 cases of syndactylia more complicated than average and among them four cases of Apert syndrome, were noted The number of polydac

tylia cases was also exceptionally low Ten of the thirteen ectrodactylia/melia cases had multiple deformities Three quarters of the 89 patients had other multiple deformities

	Male	Female	Total
Oro facial clefts	1 614	1 611	3 225
– Upper extremity deformities	53	36	89
– – Dwarfs	16	15	31
– Pterygium syndromes[1]	6	4	10
Down syndrome	6	–	6
Syndactylia	7	4	11
– – Polydactylia	3	1	4
– Ectrodactylia/melia	7	6	13
– Brachydactylia	2	2	4
– Other[2]	7	6	13

[1] Klippel Feil Sprengel Bonnevie Ullrich *Cuérin Stern* etc

[2] Symphalangism clinodactylia flexion contractures nail deformities etc

SPINAL FUSION AND THE CORRECTION OF

Helsinki

Experimental attempts to produce solid fusion of the growing spine with bone grafts have generally been unsuccessful Spine fusion experiments have therefore failed to shed much light on the clinical problems of early spine fusion Continued growth in the length of the spines of young rabbits routinely occurs after spine arthrodesis in which gross pseudarthroses have developed at each interspace

In our earlier studies a bony fusion was achieved in different regions of the thoracic and lumbar spine with free periosteal transplants In unilateral fusions this caused a progressive *scoliosis*

In the present study this new model of spinal growth disturbance was used in attempts to correct experimental scoliosis When a *progressive* scoliosis developed a free periosteal graft from the tibia of the same animal was transplanted to the convex side of the spine between the spinous and articular processes overlying the vertebral laminae

With this method it was possible to achieve spinal fusion and stop the progression of *experimental* scoliosis We conclude that with an *early* fusion a gradual straightening of slight or moderate scoliosis is possible

SPINAL FUSION OF IDIOPATHIC SCOLIOSIS WITH FREE PERIOSTEAL GRAFTS A PRELIMINARY REPORT

O Snellman K Österman & V Ritsilä
Orthopaedic Hospital of the Invalid Foundation
Helsinki

The present operative treatment of progressive idiopathic scoliosis generally consists of the Harrington method and spinal fusion The Harrington instrumentation gives a rigid fixation In our previous studies free periosteal grafts have proved to possess a strong and fast bone forming capacity both experimentally and clinically

These observations led us to use free periosteal grafting in spinal fusion of scoliosis and spondylolisthesis

The osteoperiosteal grafts were taken from the tibia with a sharp chisel. In this way it was possible to utilize the cambium layer cells and also the maximal growth potential of the graft.

A total of 55 patients were operated on The mean age of the patients was 14 5 years The fusion was performed in thoracic thoracolumbar or lumbar areas In 44 patients the indication for fusion was idiopathic scoliosis *The patients were allowed to walk on the second post* operative day with a Milwaukee brace and the brace was used for 6 months postoperatively

Biopsies were taken during a second operation *(4 6 8 12* and *24* weeks after the transplantation)

The bone formation in the fusion area occurred through an enchondral *process* It was stable and compact after 24 weeks (6 months)

HAEMATOMA OF THE ROOT SLEEVE

V M Huittinen
Kyyhkylä Rehabilitation Centre
Mikkeli

In a postmortem study aimed at the evaluation of lumbosacral nerve injuries in fractures of the pelvis a laminectomy was performed

swelling in the root sleeve was a round subdural haem*atoma with a diameter* of 2 cm which appeared at the site of the posterior root *ganglion Hist*ologically a cystic cavity around the spinal ganglion and an acute haemorrhage at the site *of both roots* were seen

The traumatic haemorrhage of the root sleeve thus *occurred* at the junction of the nerve root and *the* spinal nerve *Here the meningeal* arrangement of the nerve root sleeve ends and the *subarachnoid* space does not extend beyond the spinal ganglion The haematoma in the root

sleeve may compress the nerve roots which are less resistant to compression than the peripheral nerves themselves

These subdural haematomas on the sacral nerve root sleeve appeared to be caused by bleeding into a perineurial cyst The cysts cannot be demonstrated by an ordinary lumbar myelography A traumatic haemorrhage into the sacra perineurial cyst produces an expansion of the cyst and a compression of the nerve root This mechanism of neurological defects as a complication of injuries to the lumbosacral spine and pelvis has not been described earlier

THE TREATMENT OF LESIONS OF THE PLEXUS BRACHIALIS A PRELIMINARY REPORT

K Solonen & S Vilkki
Section of Hand Surgery
Orthopaedic Hospital of the Invalid Foundation
Helsinki

Twenty five patients with plexus brachialis lesions were treated during the period November 1972–July 1976 The injuries were mainly traumatic lesions from traffic accidents Careful preoperative examinations such as tests of muscle functions and sensibility EMG cervical myelography and histamine axon reflex studies were made

The type of operation selected was a free nerve transplantation in 15 cases suture of the plexus in one case liberation in five cases and transposition of some intercostal nerves into the plexus in four cases There are some encouraging results among the patients operated on during 1973 1974 but it is still too early—because of the long regeneration time—to make any firm conclusions about the usefulness of these pains taking operations which demand the teamwork of two orthopaedic surgeons and one micro surgeon and a good deal of time in the operating theatre

FRACTURES OF THE OLECRANON AN ANALYSIS OF 37 CONSECUTIVE CASES

O Kiviluoto & S Santavirta
Division of Orthopaedics and Traumatology
Surgical Hospital
Helsinki University Central Hospital

Thirty seven olecranon fractures were treated from 1973 to 1975 Fifteen of the fractures were transverse five oblique and 18 comminuted The treatment was operative in all but two cases Three cases were complicated by a superficial infection and in three cases the internal fixation failed The mean follow up time was 2 years

The results were evaluated as excellent in 13 cases good in 7 fair in 13 and poor in two cases Patients under 50 years did better than older ones and the results for men were better than those for women The transverse fractures healed as expected more satisfactorily than the comminuted ones In the comparison of methods of internal fixation cerclage combined with two Kirschner wires was better than cerclage alone An immobilisation of 3 weeks or less gave the best results

We suggest that internal fixation with two Kirschner wires and cerclage should be the method of choice in most cases Immobilisation should not exceed 3 weeks

Acta orthop scand 48 341–344 1977

PROCEEDINGS OF THE NORWEGIAN ORTHOPAEDIC ASSOCIATION

EDITOR ARNT JAKOBSEN

Oslo, September 25th, 1976

A DISCUSSION OF THE MECHANICS OF CURVE DEVELOPMENT IN IDIOPATHIC SCOLIOSIS

James A Ashton Miller
Sophies Minde Orthopaedic Hospital
Oslo

Variables affecting the mechanics of curve development in idiopathic scoliosis were discussed The simple analogy of a slender elastic rod loaded in axial compression was used Axial forces were assumed to consist of both muscular and gravitational components Particular emphasis was placed on the concept of structural stability Modifications of the simple analogy to account for some of the anatomical and physiological properties of the spine *in vivo* were also discussed

Oslo, October 22nd 23rd 1976 (Annual Meeting)

SPONTANEOUS OSTEONECROSIS OF THE KNEE

Cale Uppheim
Kronprinsesse Märthas Institutt
Oslo

Spontaneous osteonecrosis of the medial femoral condyle in the absence of known disposing factors chiefly affects persons aged 60 years and over

There is a sudden onset of pain Radiographic changes develop 4–5 months later These consist of flattening of the condyle a subchondral radiolucent line with a sclerotic halo and a necrotic bone plate in the defect The changes are located on the weightbearing surface of the condyle

Before the development of radiographic changes the diagnosis can be confirmed by *radionuclide scintimetry* Small lesions with high focal scintimetric activity have the best prognosis as regards the development of osteoarthritis High tibial wedge osteotomy with valgisation or prosthetic replacement surgery may be necessary

Three cases with typical symptoms and findings were demonstrated

THE CHANGED PATTERN OF BONE AND JOINT TUBERCULOSIS IN NORWAY

Bernhard Paus
Martina Hansens Hospital
Sandvika

The reduced incidence and the change in the affected age groups in bone and joint tuberculosis in Western countries are well known In addition there are other but less conspicuous changes multiple lesions and involvement of the spine and sacro iliac joint are now more seldom while trochanteric involvement occurs more frequently In spinal cases the lesion is more often localized to the dorsal region than before All these changes may be due to the change in age distribution of the patients

MECHANICAL PROPERTIES OF CORTICAL BONE

Terje Terjesen
Regional Hospital
Trondheim

Tension tests were performed on human cortical bone from the femoral diaphysis, removed during routine autopsy of 10 individuals aged 15 to 85.

Four different strain rates were used which gave fracture after 5 minutes at the slowest velocity and at $^1/_{10}$ of a second at the fastest. With increasing strain rate ultimate stress increased but no difference was found in ultimate

sleeve may compress the nerve roots which are less resistant to compression than the peripheral nerves themselves

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strain There was no difference between the age groups above and below 60 years as regards average ultimate stress Ultimate strain decreased significantly with increasing age This indicates that cortical bone in young individuals tolerates greater deformation before fracture than bone in older persons

LARSEN S SYNDROME

Helge Ronningen
Sophies Minde Orthopaedic Hospital
Oslo

Larsen s syndrome includes facial abnormalities laryngotracheomalacia and multiple dislocations One case a female is reported She had a depressed nose bridge and widely spaced eyes a dislocated right knee bilateral pes equinovalgus and pectus excavatum Radiographs showed an additional ossification centre of the calcaneus Laryngoscopy showed laryngomalacia

Mors subita supervened at 9 months of age in a state thought to be a cyanotic attack Autopsy revealed a marked laryngo tracheomalacia with soft flappy epiglottis and a tendency to tracheal collapse

TREATMENT OF PERTROCHANTERIC FRACTURES WITH KUNTSCHER S CONDYLOTROCHANTERIC INTRAMEDULLARY NAIL AND McLAUGHLIN S PLATE AND NAIL

Astor Reigstad Pål Benum & Gunnar W Vestby
Ullevål Hospital
Oslo

A retrospective comparative study of 107 patients treated with McLaughlin s plate and nail and 104 with Küntscher s intramedullary nail for pertrochanteric fractures is reported Mean hospital stay was 34 1 and 20 5 days respectively ($P < 0\ 001$) the mortality within 3 weeks after operation 8 4 and 7 7 per cent The mean duration of the anaesthesia was 111 and 81 minutes respectively ($P < 0\ 001$) the mean operating time 67 and 38 minutes ($P < 0\ 001$) Patients treated with McLaughlin s method needed significantly more blood transfusions than those who had Kuntscher s nail Consolidation of the fracture occurred within 8 weeks in 68 6 and 87 per cent ($P < 0\ 01$) of the patients respectively whereas healing periods exceeded 12 weeks in 20 and 2 9 per cent respectively Penetration of the nail through the head/neck of the femur occurred most often in the patients with intramedullary nailing Complications which severely affected the patients during the healing period or influenced the final result occurred in 22 5 and 16 7 per cent respectively Pain and stiffness of the hip seldom occurred in patients with Kuntscher s nail and there were less problems mobilizing the patients after this operation There were considerable complaints regarding the knee in 11 patients in this group all recovering after removal of the nail

It is concluded that Kuntscher s method is superior to the plate and nail method in pertrochanteric fractures The former procedure is simple provides stable fixation and fast healing

TORSION DEFORMITIES FOLLOWING TRACTION TREATMENT OF FEMORAL FRACTURES IN CHILDREN

P Benum K Ertresvåg & A Hoiseth
Regional Hospital
Trondheim

The torsion of both femurs was investigated in 55 patients who had been treated 5 to 13 years earlier at the age of 1 to 16 years for femoral shaft fractures By comparing the anteversion angle of the contralateral hips determined by the Rippstein method torsion deformities exceeding 10° were found in the fractured femur of 10 patients The maximal deformity was + 27° Deformities appeared more frequently in patients treated with adhesive overhead traction of the fractured leg than in patients treated with wire traction with the limb placed on an oblique frame There was no correlation between age at the time of injury and torsion deformities and no correlation between the length of the observation period and torsion deformities

ON THE MECHANICS OF CURVE DEVELOPMENT IN IDIOPATHIC SCOLIOSIS

James A Ashton Miller
Sophies Minde Orthopaedic Hospital
Oslo

Simplified theoretical models of the spine were discussed with particular reference to variables affecting its structural stability in idiopathic scoliosis These included the geometry material properties rate of growth and external loading of the adolescent vertebral column

TOTAL HIP ARTHROPLASTY IN PREVIOUSLY INFECTED HIPS

Hans K Dahl
Ullevål Hospital
Oslo

Material Twelve cases of previously infected hips were operated eight in one stage four in two stages with insertion of a new Charnley Müller prosthesis fixed with Palamos Garamycin ® cement

Seven cases had a total hip arthroplasty, three cases a cup arthroplasty, and two cases a nailed fracture of the neck of the femur

Staphylococcus aureus was cultured in six hips and in four active infection was present In six hips a definite clinical infection was or had been present, but bacteriological examination was negative

Postoperatively immediate weightbearing was allowed and systemic antibiotic medication was continued for 2 months

Results One patient died 2 weeks after the second stage of severe haemorrhage from stress ulcer, and severe heart infarction

In 11 cases primary healing occurred and there was no recurrence of infection during the observation time (3 months to 2 years) All patients had a pain free hip and good stability

Conclusion It seems advisable to replace an infected hip prosthesis and an infected fracture of the neck of the femur with a new prosthesis fixed by Palamos Garamycin® cement and combine this with prolonged antibiotic medication postoperatively

Oslo, November 20th, 1976

CONGENITAL ELEVATION OF THE SCAPULA

Rolf Daus
Vestfold Central Hospital
Tønsberg

One case operated according to J W Woodward with a good result is reported

CONGENITAL RADIAL CLUB HAND

Rolf Daus
Vestfold Central Hospital
Tønsberg

A preliminary report is given of a case showing no anomaly of the radius which was treated conservatively for the first year

MONTEGGIA FRACTURES IN CHILDREN

Tor Leif Flornes
Vestfold Central Hospital
Tønsberg

Three cases are reported It is asserted that the Monteggia fracture occurs more frequently in children than is commonly supposed The surgeon's responsibility to discover the dislocated head *of the radius is stressed, because* this is often missed by the radiologist

GALEAZZI FRACTURES

Einar Wollebæk
Vestfold Central Hospital
Tønsberg

This is an isolated overlapping fracture involving the distal two thirds of the radius with *an associated* disruption of the distal radio ulnar joint Four cases treated with osteosynthesis are reported

Oslo, December 18th, 1976

DOG BITE

Arve Sæbø
Akershus Central Hospital
Nordbyhagen

Out of eleven patients admitted for severe dog bites five were less than 10 years old. Six were wounded in the face one in the face and hand and four in the upper extremities only Nine were admitted without delay Two instances of infection were observed in seven patients who had their wounds revised and sutured out of two only sutured one became infected Two were admitted late with infected wounds Of the five patients with wound infection three were diabetics and in one case no antibiotics had been administered In two instances late complications occurred Partial facial nerve palsy persisted in one case, and osteomyelitis necessitated amputation of a finger in the other

BELOW KNEE AMPUTATION FOR ISCHAEMIC VASCULAR DISEASE

Arve Sæbø & Gunnar Follerås
Akershus Central Hospital
Nordbyhagen

In the period 1971 to 1975 127 patients were treated with major amputations of the leg for

strain There was no difference between the age groups above and below 60 years as regards average ultimate stress Ultimate strain decreased significantly with increasing age This indicates that cortical bone in young individuals tolerates greater deformation before fracture than bone in older persons

LARSEN S SYNDROME

Helge Ronningen
Sophies Minde Orthopaedic Hospital
Oslo

Larsen s syndrome includes facial abnormalities laryngotracheomalacia and multiple dislocations One case a female is reported She had a depressed nose-bridge and widely spaced eyes a dislocated right knee bilateral pes equinovalgus and pectus excavatum Radiographs showed an additional ossification centre of the calcaneus Laryngoscopy showed laryngomalacia

Mors subita supervened at 9 months of age in a state thought to be a cyanotic attack Autopsy revealed a marked laryngo tracheo malacia with soft flappy epiglottis and a tendency to tracheal collapse

TREATMENT OF PERTROCHANTERIC FRACTURES WITH KUNTSCHER S CONDYLOTROCHANTERIC INTRAMEDULLARY NAIL AND McLAUGHLIN S PLATE AND NAIL

Astor Reigstad Pål Benum & Gunnar W Vestby
Ullevål Hospital
Oslo

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A HISTOLOGICAL DEMONSTRATION OF NERVES IN SUBCHONDRAL BONE

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Several different staining procedures were carried out on decalcified histological sections from human femoral heads to demonstrate the nerves in subchondral bone The femoral heads were obtained at surgery from patients with fractures of the femoral neck or osteo arthritic hip joints The Bodian technique was found to be the most suitable Serial sections were used in order to disclose the various sources of error It was not possible to demonstrate nerves in the bone matrix but they were easily seen in the subchondral bone marrow aften related to the vessels A comparison of the fracture and osteo arthritic cases revealed an obvious difference more nerves were seen in osteoarthritis The method described is considered suitable for further study of the nerves in osteoarthritic femoral heads

Key words innervation subchondral bone osteoarthritis

Accepted 3 vi 77

Relatively few articles have been pub lished in recent literature, about the nerve supply of bone and textbooks of histology hardly mention the subject This is probably due to the difficulties encountered in working out a reliable technique The presence of nerves in bone has been demonstrated in the peri ost in the endosteum of the medullary trabeculae and in the bone marrow, by light microscopy (Sherman 1963, Leeson & Leeson 1970, Miller & McCuskey 1973)

The fact that nerves also occur in the Haversian canals has been shown by elec tron microscopy (Milgram & Robinson 1965) but it is still a matter of discus sion whether or not nerve fibres are present in the bone matrix Thus, Sher man (1963) Miller & Kasahara (1963), Milgram & Robinson (1965) and Cooper (1968) were unable to confirm the ob servations of De Castro (1930) and Hurrell (1937) De Castro described nerve fibres in growing bone in cats, often closely related to the osteocytes, and Hurrell demonstrated nerve fibres in the bone matrix of a fully grown cat There have been no similar observations in human bone

The ne[illegible] non my[illegible] have al[illegible] It is still not fully elucidated how the nerves end in bone

This work is an attempt to find a suitable technique for demonstrating nerves in subchondral bone in human femoral heads and to describe some pre liminary findings in osteoarthritic fem oral heads

ischaemic gangrene, 58 above- and 69 below-knee The trend has been towards below-knee amputations In 1971 above-knee amputations amounted to 82 per cent; in 1975 this figure was 18 per cent

The age was between 60 and 90 years, 32 were diabetics "The sagittal flap technique" was used in 59 patients; in 10 the conventional long posterior, short anterior flap technique Postoperative mortality was 9 per cent, and necrosis and infection occurred in 37 per cent Re-amputation at higher levels was necessary in 6 per cent of the diabetics, and in 37 per cent of those with simple atherosclerosis

In 36 patients rehabilitation with prosthesis was considered possible, but only 23 were able to use their prosthesis with benefit

At present below-knee amputation is used as a standard procedure, except in patients where the gangrene extends to a high level on the lower leg

SLIPPING RIB SYNDROME

Jorund Asle Holme
Akershus Central Hospital
Nordbyhagen

This syndrome is due to displacement of the anterior end of the anterior cartilages of the eighth, ninth or tenth ribs because of loosening of their fibrous attachments

Attacks of painful sensations localized to the costal arch, always preceded by a movement involving the muscles of this region, are the usual complaints The symptoms are often misinterpreted and thought to be caused by a hernia since the deformity which develops is reducible

Three female patients with symptoms lasting from 1 to 5 years were operated with resection of the rib cartilage All were improved

ONE HUNDRED ASIF-PLATED FRACTURES OF THE FEMORAL SHAFT

Rolf Grontvedt & Thorleif Wilhelmsen
Akershus Central Hospital
Nordbyhagen

One hundred femoral shaft fractures, 29 comminuted and 12 open, were treated with the lateral ASIF plate

Road traffic accidents caused the fracture in 68 patients of whom 28 were car occupants and 26 motorcycle riders Serious accompanying injuries were frequent, mainly head injuries and various fractures Three had rupture of the femoral artery

Two elderly patients died from cardiopulmonary diseases Osteomyelitis developed in two, non-union in two healed after re-operation Fat embolism was not seen in 17 patients who were operated upon a few hours after admission, but occurred in 5 patients primarily treated with skeletal traction for 1 week



Figure 2 Osteocyte lacuna and canaliculi stained by Bodian Canaliculi are seen with a double outline and a non coloured zone in the centre This can only be demonstrated by using high magnification and focussing (Bodian orig magnification × 1000)



Figure 3 Subchondral bone and bone marrow from a femoral head from a patient with fracture of the femoral neck Cross section of a small nerve (arrow) in association with vessels (Haematoxylin eosin orig magnification × 100)

to cross the lamellae it was necessary to study serial sections in order to find whether the lines were present in more than one of the serial sections (Figure 1 A and B)

Staining located to the endost osteochondral junction and tidemark was never interpreted as nerves Finally Sharpey's fibres which cross the lamellae should be mentioned but the acid used for decalcification impairs the colour as the fibres consist mainly of collagen

RESULTS

Histological sections from the cases with fracture of the femoral neck After elimination of the above mentioned sources of error, it was not possible to demonstrate nerve fibres in the bone matrix by the Bodian method However, in the bone marrow, nerves were easily demonstrated, usually closely associated with the vessels Whereas the myelin sheath staining gave negative results, staining with haematoxylin eosin and v Gieson showed some cross sections of nerves in the marrow related to the vessels (Figure 3)

Histological sections from osteoarthritic femoral heads It was also not possible to demonstrate nerve fibres in the bone



Figure 1 A Subchondral bone from osteoarthritic femoral head illustrating staining of cement lines Due to osteoarthritic alterations the arrangement of lamellae differ from that seen in normal bone (Bodian orig magnification × 100) B A serial section from the same sample at a distance of 6 μ The cement lines are easily recognized

MATERIAL AND METHODS

Twelve femoral heads were obtained from patients at the time of arthroplastic replacement after fracture of the femoral neck (two control material) or osteoarthritis (ten) Immediately after operation the specimens were preserved in 10 per cent buffered formaline phosphate Equal slices 10 mm thick were obtained from each head with a hand saw The slices included the circumference of the head with articular cartilage and subchondral bone from both weight bearing and non weightbearing areas After decalcification in 10 per cent formic acid and embedding in paraffin the samples were cut in serial sections at 6 μ and subsequently stained

The Bodian method was used for axon staining and staining of the myelin sheaths was performed according to the method of Mahon and Weill In addition staining with haematoxylin eosin and v Gieson was performed

The final evaluation was based on the histological sections stained with Bodian s method In the present work a modification used routinely at the Laboratory of Paediatric Pathology Rigshospitalet was used It is as follows

1 Deparaffinize and hydrate with distilled water
2 Place slides in protargol solution 1 per cent and add 6 g of clean copper shot per 100 ml of solution Let stand at 37° C for 24 hours
3 Rinse in distilled water, three changes
4 Staining solution for approximately 5 minutes 4 ml silver nitrate (10 per cent) with supersaturated sodium sulphite until clear Add 3 ml of this solution to 300 ml gum arabic and shake for 5 minutes then add 30 ml 2 per cent hydroquinone
5 Rinse in distilled water three changes
6 Tone in gold chloride solution 1 per cent with addition of three drops glacial acetic acid per 100 ml solution Tone for 5 minutes
7 Rinse in distilled water three changes
8 Develop in oxalic acid (2 per cent) approximately 5 minutes
9 Rinse in distilled water three changes
10 Sodium thiosulphate (5 per cent) for 5 minutes
11 Rinse in distilled water dehydrate in alcohol and clear in xylene

It was necessary to work out methods which would eliminate the various sources of error as structures other than nerve fibres in the bone become stained by the Bodian method (Figures 1 and 2) e g both canaliculi and lacunae become stained black In doubtful cases where canaliculi resembled nerves it was possible to show by light microscopy (magnification × 1000) that the black colour in canaliculi appears as a lining and consequently the canaliculi are seen with a double outline enclosing a non coloured zone (Figure 2) The cement lines between the different systems of lamellae were also stained by Bodian s method When a black line appeared



ı ıgn f cntı n × 1000) C Solitary nerve in the bone marrow (arrow) (Orig magnification × 100)
D Same as C (Orig magn f cat on × 400)



Figure 4 Subchondral bone from osteoarthritic femoral head. *A* Longitudinal section of a nerve fibre (arrow) related to an arteriole (Bodian; orig. magnification × 100). *B* Same as *A* (Orig.



Figure 6 A Subchondral bone (cartilage absent) from osteoarthritic femoral head Nerve (arrow) is seen located in a cyst with granulation tissue (Bodian orig magnification × 100) B same as A (Orig magnification × 1000)

matrix are stained black in the same way as the nerves (Green et al 1970) This applies to the osteocyte lacunae and particularly to canaliculi as they are lined with sulphated mucopolysaccharide Ham 1969) According to Leeson & Leeson (1970 the black stained cement lines also contain mucopolysaccharide The authors confirm this by staining the sections with Alcian Blue an obvious green colour was then seen located to the osteocyte lacunae and to a minor degree to the canaliculi and a diffuse green glow was seen in some sections of the bone matrix contrasting with the red colour of the bone

According to Bodian (1937) treatment with acid should impair the colour of collagen and thus eliminate structures such as Sharpey s fibres This was confirmed by staining sub synovial fibrous tissue with Bodian after treatment with 5 per cent acetic acid

Decalcification has been discussed Hurrell (1937) who used 6 per cent nitric acid to decalcify mentioned that it was necessary to use alum to prevent swelling of the matrix caused by the acid This on the other hand interferes with the impregnation of the soft tissue Rowles & Brain (1959) used 10 per cent formic acid to decalcify sections of teeth before staining nerve fibres with silver and Gough (1970) stated that 10 per cent formic acid could be used to decalcify before silver impregnation



Figure 5 A. Subchondral bone and cartilage from osteoarthritic femoral head. Vessels penetrate from the subchondral marrow. Solitary axon is seen accompanying the vessels (arrow) (Bodian orig magnification × 100). B. Same as A (Orig magnification × 1000).

matrix in these sections by Bodian's method. However, several nerve fibres, in longitudinal as well as cross sections, were seen in the bone marrow subchondrally where an abundance of vessels were also found (Figure 4 A, B, C, & D). As nerves were also demonstrated in sections with a proliferation of vessels into the calcified layer of articular cartilage (Figure 5 A & B), as well as in the subchondral granulation tissue (Figure 6 A & B) it was evident that there were more nerves in the osteoarthritic femoral heads than in the control cases.

The other staining methods gave results similar to those described for the sections from the fracture cases.

DISCUSSION

The distribution, character and ending of nerves in bone have not been fully elucidated.

In the present work the method of Bodian (1936, 1937)—an accepted axon staining method—was chosen as almost all nerve fibres in bone are unmyelinated (Cooper 1968) and, furthermore, as myelin sheath staining in our experience produced only negative results.

In analysing the decalcified sections of bone stained with Bodian's method, many considerations were taken into account concerning the method and results. Bodian staining is not specific for nerve fibres as many other structures in the bone

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ARTERIAL EMBOLIZATION FOR RADICAL TUMOR RESECTION

D PATEL, O CROTHERS, W. H HARRIS, A WALTMAN, N FAHMY & R. CAREY

Departments of Orthopedic Surgery, Radiology, Oncology, and Anesthesia of the Massachusetts General Hospital, and the Harvard Medical School, Boston, Massachusetts USA

Two contemporary measures, selective transarterial embolization (Almgard et al 1973) and controlled hypotensive anesthesia (Davis et al 1974), have been combined in an effort to reduce the risk of operative bleeding in a case of massive bone and muscle resection of a highly vascular carcinoma lesion in the proximal third of the femur This approach may be helpful in such cases

Key words bone neoplasia resection, controlled hypotension, selective arterial embolization

Accepted 25 iii 72

Severe hemorrhage during radical operations for excision of malignant lesions remains a potential, serious risk A case is reported in which an effort to reduce this risk was made by combining preoperative transarterial embolization and intraoperative-induced hypotensive anesthesia The operation involved resection of the proximal half of the femur with surrounding muscles and insertion of a proximal femoral replacement total hip implant

CASE REPORT

A 45 year old man was admitted for treatment of a metastatic lesion of the left proximal femur Eight months previously he began having intermittent aching in his left knee Three months later, x ray examination revealed an osteolytic lesion of the left proximal femur No primar [illegible] of the [illegible] hospita [illegible] blood loss was impressive Two units of blood had to be given and the small biopsy wound had to be packed in order to obtain hemostasis Pathological evaluation of the specimen revealed "metastatic carcinoma—primary unknown" Mithramycin[1] was begun and 3000 rad of supervoltage Cobalt 60 radiation were given Two months later he was placed in a spica cast because of increasing pain in his left hip, and he was begun on vincristin sulfate[2], Cyclophosphamide[3] and 5 fluorouracil[4] When admitted to the Massachusetts General Hospital pain in his hip was intolerable despite being in the spica cast X-ray films revealed substantial extension of the tumor with two pathologic fractures, one in the femoral neck and another in the proximal femoral shaft (Figure 1)

Again a primary focus could not be identified, nor other secondary lesions It was decided to resect the proximal femur and surrounding soft tissues *en bloc* and to perform replacement arthroplasty with a custom Mueller proximal femoral replacement prosthesis Prophylactic

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[1] Mithracin, Pfizer, Inc, New York, New York

[2] Oncovin, Eli Lilly and Company, Indianapolis, Indiana

[3] Cytoxan, Mead Johnson Laboratories, Evansville, Indiana

[4] Fluorouracil, Roche Laboratories, Nutley, New Jersey

In the present study, 10 per cent formic acid was also used As in recent years undecalcified sections have been used routinely in many laboratories, sections were also prepared for Bodian staining after they had been embedded in methyl methacrylate, however, as details in the bone matrix were not so distinct, we preferred the decalcified sections

Only subchondral bone from human femoral heads has been examined in this work In the sections from "normal" bone it was not possible, after eliminating several sources of error, to demonstrate nerve fibres in the bone matrix, but only in the marrow In sections from osteoarthritic femoral heads it was obvious that there was an increased number of nerves, as they were related to the increased amount of vessels subchondrally in the bone marrow and in the granulation tissue

From this preliminary work it may be concluded that there seems to be a greater number of nerves in osteoarthritic subchondral bone than in normal bone, and this is probably by analogy with the increased vascularization The subject may be used for further studies, as the various causes of pain in osteoarthritis are still not quite elucidated

ACKNOWLEDGEMENTS

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Figure 3 Antero posterior roentgenogram of the left hip area showing the proximal femoral replacement total hip arthroplasty

plications of the angiography the embolization [illegible]

[illegible]

[illegible] differentiated adenocarcinoma probably of gastrointestinal origin" No primary lesion was found Thirty six months after his operation he was ambulatory with *one cane* had no pain and had returned to work The lesion had not recurred

DISCUSSION

Three factors contributed to the reduced blood loss in the excision of this highly vascular tumor namely induced hypotensive anesthesia selective arterial embolization and *en bloc* excision A prospective controlled series is needed to prove a significant reduction had occurred and to establish which of the three factors was most valuable However, the experience during the biopsy in this case and experiences with other similar replacement operations with induced hypotensive anesthesia and preoperative selective arterial embolization suggest strongly to the authors that these measures were helpful

Stener (1962) described the method of temporary arterial occlusion for the purposes of reducing operative bleeding and to lessen the risk of the tumor spreading However, this method of temporary occlusion requires an abdominal incision in addition to the large incision needed in this case to remove the tumor Since preoperative arteriography was necessary for evaluation of the vascularity of the tumor, little extra time or risk was involved in arterial embolization while the catheter was in place for this study Arterial embolization preoperatively has been used in reducing the circulation to malignant tumors in urologic surgery (Almgard et al 1973)

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Figure 1 Arteriogram of the left hip region showing marked vascularity of the metastatic lesion



Figure 2 Repeat arteriogram immediately after introduction of Gelfoam clot showing obstruction of the major arteries going to the tumor The extensive destruction of bone and the two pathologic fractures in the subtrochanteric region can be seen on this film

anticoagulation with warfarin[5] was instituted because of high thromboembolic risk following total hip replacement surgery (THR) (Coventry et al 1973) because his operation was to be more extensive than the usual THR and because he was to be in bed for 6 weeks postoperatively

A catheter was introduced via the opposite femoral artery to study the vascularity of the tumor, the major feeding vessels and the collateral circulation Arteriography of the left common iliac external and internal iliac arteries demonstrated that the major supplying vessels arose from external iliac Little collateral circulation was present At the same time absorbable gelatin sponge[6] fragments were introduced transarterially as emboli to occlude the major feeding vessel Figure 2) In order to avoid an increase in collateral circulation the surgery was performed within 24 hours

The following day under halothane[7] general anesthesia controlled hypotension was induced with pentolinum tartrate[8] The tumor was excised *en bloc* and the custom design total hip replacement was performed (Figure 3) The excised mass was 20×11×7 cm Total measured intraoperative blood loss was 2 500 cm³ One unit of blood was given preoperatively because his hematocrit was 29 per cent He received six units the day of surgery and one unit of blood 9 days postoperatively Total blood replacement during this admission was eight units

The postoperative course was benign No com

5 Coumadin Endo Laboratories Garden City New York

6 Gelfoam The Upjohn Company Kalamazoo Michigan

7 Fluothane Ayerst Laboratories New York New York

8 Ansolysen Wyeth Laboratories Philadelphia Pennsylvania

Control material

Studies of fracture incidence in a normal population have been carried out earlier in the city of Malmo (210 000 inhabitants), and have included fractures of the forearm (radius) (Alffram & Bauer 1962) cervical and trochanteric fractures of the femur (Alffram 1964), ankle fractures (Nilsson 1969) and fractures of the upper end of the humerus (Horac & Nilsson 1975) In this investigation we have compared ... of non seizure-

in

re

in these bones in a normal population

*Statistical methods**

Using the hypothesis that the group of patients under study are exposed to fractures at no higher than the normal rates the expected number of fractures of each type in each age and sex group during the period of study can be computed as the product of the normal group rate by the number of patients in the group by the number of years under study A significantly higher number of observed fractures in any group indicates that this group is exposed to fractures at a higher rate than the normal group

To determine what should be meant by a significantly higher number of observed fractures the instances of fracture are considered as occurring randomly in time and independently of each other This somewhat idealized model immediately leads to the consequence that the number of observed fractures in any one group is Poisson-distributed with the mean equal to the

ical levels of significance can readily be computed Also because of the additive property of Poisson variables (i e the sum of independent Poisson variables is itself Poisson distributed, with the mean equal to the sum of the means of the variables) both the expected and the observed numbers in any set of subgroups can be added to form a larger group and the same type of test can then be used for this new group

The large number of single tests allowed by this material (in the order of 100) makes it necessary to consider the problem of spurious significance A series of 100 independent tests, each performed on the 5 per cent level will obtain on the average five spurious significances and so forth. To keep down the risk of spurious significances, a much lower level has to be used in each test To make the risk of one spurious significance 1 per cent, each test has to be performed on the 0 01 per cent level of significance

* Statistical calculations were performed by Per Overbeck Department of Mathematical Statistics University of Lund

RESULTS

Fifty-three epileptics had no fractures during the 7-year period Thirty-four had 70 fractures Of these, 26 were with certainty related to epileptic seizures and 44 probably not related to seizure Table 1 shows the type of fracture

Of the fractures, 35 in number, for which we have incidence *totals from the* Malmö surveys, 22 in 17 epileptics were probably not related to seizures (Table 1) These we have studied further The mean age for the 17 epileptics was 61 ± 8 years

In Tables 2-6 a comparison is made between the expected number of frac-

Table 1 Seventy fractures in 34 epileptic patients

Site of fracture	Men	Women
Humerus neck	2 (1)	2 (2)
Radius	4 (1)	3 (1)
Femur neck	1	5
Femur trochanter	4 (3)	4
Ankle (mall ped)	5 (2)	5 (3)
Clavicle	3 (3)	1
Humerus supracondyle	0	1 (1)
Olecranon	0	1
Hand	2 (2)	3 (1)
Vertebrae	0	2 (1)
Pelvis	1 (1)	3
Femur-supracondyle	0	4
Tibia-condyle	0	6 (1)
Tibia and fibula	1	1
Foot	1 (1)	5 (2)
Total	24 (14)	46 (12)
Total	70 (26)	

The numbers within parentheses indicate fractures which have occurred during epileptic seizures

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INCIDENCE OF FRACTURE IN EPILEPTICS

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In 87 epileptics on diphenylhydantoin, the occurrence of non seizure related fractures, over a period of 7 years was six times greater than that found in the normal population The significant increase in fracture incidence was found to lie within the 45-64 age group indicating that epileptics are not only more prone to fractures but also have an earlier fracture début

Key words diphenylhydantoin, epilepsy, fracture, osteomalacia

Accepted 17 iii 77

A great number of studies in recent years have shown that 25 per cent of all patients undergoing antiepileptic treatment develop osteomalacia This finding is based on blood chemistry tests and on X-ray examinations (Dent et al 1970, Hunter et al 1971, Borgstedt et al 1972, Christiansen et al 1972, Kraft et al 1974, Livingstone & Pauli 1974, Kruse 1975) A high incidence of fracture in epileptic patients can be expected because of the nature of the illness (Vasconcelos 1973), but no investigation of this subject can be found in the literature The aim of the present study, which is part of a larger survey, has been to compare the incidence of fractures not related to seizures in 87 epileptics, over a period of 7 years, with the expected incidence in a normal population

MATERIAL AND METHODS

Proband material

The material comprises 87 epileptics 49 women and 38 men The mean age for the women was 56 ± 12 years and for the men 55 ± 12 years Most of the epileptics have suffered from the disease since childhood and all have been on anticonvulsant therapy for more than 10 years in most cases on diphenylhydantoin (200-500 mg average dose 350 mg) and Phenemal (100 mg) More recently Mylepsin has been prescribed for a few patients Serum concentration determination of diphenylhydantoin has not been carried out routinely Most of the epileptics are debilitated to a minor degree but have had steady employment and lived in their own apartments in a home for epileptics (Fogdarodshemmet) None of them have been on general steroid therapy Two have diabetes mellitus and one has rheumatoid arthritis but these three are not included in the fracture group

In cases of serious skeletal damage examinations have been carried out in one of three X ray units We have gone through the archives in all three units for the period January 1969 through December 1975 During this time all of the patients in the present study lived in the above mentioned home This has made it possible for us to register the majority of the more serious fractures At the same time with the help of the personnel at the home and by studying the referrals for X ray examination we have been able to differentiate the fractures which have occurred in connection with epileptic seizures

Table 5 Observed frequency of trochanteric fractures of the femur (Fract troch fem) in epileptic patients as compared with expected frequency in the normal population

Age		25–44 years	45–54 years	55–64 years	65–74 years	75–79 years	Total
Men	Obs freq	0	0	0	1	0	1
							$P > 0.05$ 1
	Exp freq	0.0019	0.0037	0.0178	0.0606	0	0.0840
Women	Obs freq	0	0	3	1	0	4
							$P < 0.0001$***
	Exp freq	0.0007	0.0049	0.0391	0.0899	0.0461	0.1807
Total	Obs freq	0	0	3	2	0	5
							$P < 0.0001$***
	Exp freq	0.0026	0.0086	0.0569	0.1505	0.0461	0.2647

Table 6 Observed frequency of ankle fractures (Fract mall pedis) in epileptic patients as compared with expected frequency in the normal population

Age		25–44 years	45–54 years	55–64 years	65–74 years	75–79 years	Total
Men	Obs freq	0	1	1	1	0	3
							$P < 0.01$*
	Exp freq	0.0707	0.0420	0.1001	0.0651	0	0.2779
Women	Obs freq	0	0	1	0	1	2
							$P > 0.05$ 1
	Exp freq	0.0413	0.0391	0.1764	0.1134	0.0056	0.3758
Total	Obs freq	0	1	2	1	1	5
							$P < 0.001$**
	Exp freq	0.1120	0.0811	0.2765	0.1785	0.0056	0.6537

tures in 87 persons over a period of 7 years and the observed number in the epileptic group The fractures are classified according to type This comparison is also shown for the totals graphically in Figure 1

In adding together the totals for the various types (Tables 2 6), we find that the significant increase in the occurrence of fractures appears in the 45 54 and 55 64 age groups (Figure 1) The ex

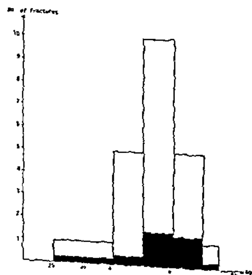


Figure 1 Observed frequency of fractures not related to seizures in 87 epileptics (open columns) as compared with frequency in the normal population (filled columns) over a 7 year period

Table 2 *Observed frequency of fractures of the upper end of the humerus (Fract colli humeri) in epileptic patients as compared with expected frequency in the normal population*

Age		25–44 years	45–54 years	55–64 years	65–74 years	75–79 years	Total
Men	Obs freq	0	1	0	0	0	1
							$P > 0.05$ †
	Exp freq	0.0147	0.0189	0.0770	0.0910	0	0.2016
Women	Obs freq	0	0	0	0	0	0
							$P > 0.05$ †
	Exp freq	0.0210	0.0406	0.2016	0.1848	0.0392	0.4872
Total	Obs freq	0	1	0	0	0	1
							$P > 0.05$ †
	Exp freq	0.0357	0.0595	0.2786	0.2758	0.0392	0.6888

Table 3 *Observed frequency of forearm fractures (Fract radii) in epileptic patients as compared with expected frequency in the normal population*

Age		25–44 years	45–54 years	55–64 years	65–74 years	75–79 years	Total
Men	Obs freq	0	2	0	1	0	3
							$P < 0.001$
	Exp freq	0.0266	0.0112	0.0567	0.0385	0	0.1330
Women	Obs freq	0	0	2	0	0	2
							$P > 0.05$ †
	Exp freq	0.0385	0.1120	0.6930	0.5103	0.0798	1.4336
Total	Obs freq	0	2	2	1	0	5
							$P > 0.05$ †
	Exp freq	0.0651	0.1232	0.7497	0.5488	0.0789	1.5666

Table 4 *Observed frequency of cervical fractures of the femur (Fract colli fem.) in epileptic patients as compared with expected frequency in the normal population*

Age		25–44 years	45–54 years	55–64 years	65–74 years	75–79 years	Total
Men	Obs freq	1	0	0	0	0	1
							$P > 0.05$ †
	Exp freq	0.0032	0.0039	0.0356	0.0658	0	0.1085
Women	Obs freq	0	1	3	1	0	5
							$P < 0.0001$***
	Exp freq	0.0028	0.0125	0.1058	0.1959	0.0701	0.3871
Total	Obs freq	1	1	3	1	0	6
							$P < 0.0001$***
	Exp freq	0.0060	0.0164	0.1414	0.2617	0.0701	0.4956

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pected incidence for the age group 45–54 years is 0 3 fractures, whereas the observed incidence is 5 0 ($P < 0\ 0001^{***}$); the expected incidence for the age group 55–64 years is 1 5 and the observed is 10 0 ($P < 0\ 0001^{***}$)

The expected fracture incidence for men, for the five fracture types, is 0 8 and the observed incidence is 9 0 ($P < 0\ 0001^{***}$) The expected incidence for women is 2 9 fractures, while the observed incidence is 13 ($P < 0\ 0001^{***}$). The consolidated totals show an expected incidence of 3 7 fractures and an observed incidence of 22 ($P < 0\ 0001^{***}$).

DISCUSSION

Several reports on osteomalacia in epileptic patients have appeared in the literature in recent years and it has been suggested that antiepileptic therapy, especially diphenylhydantoin, is the cause of the skeletal changes and that osteomalacia in epileptics is probably related to a relative deficiency of vitamin D or of its metabolites Epileptics with osteomalacia have a low urine-calcium value, a high level of alkaline phosphates, and, in 10–20 per cent of cases, a low serum-calcium value The low serum-calcium rate can in turn possibly cause cramp attacks and antiepileptic therapy can mask this effect (Gharib & Munoz 1974)

Vitamin D_3 (cholecalciferol) can be produced in the skin through the effect of ultra-violet light, or it can be absorbed from the intestinal canal A first step in the hydroxylation process occurs in the liver, producing 25-hydroxycholecalciferol This metabolite is probably not active but circulates in the blood The next hydroxylation process occurs in the kidneys, producing the active metabolite 1 25-dihydroxycholecalciferol This metabolite affects the mucous membranes of the small intestine, the kidney tubuli and the bone tissue, principally by increasing the organism's absorption-reabsorption of calcium and phosphorus and also regulates the mineralization of bone tissue The hydroxylation process is probably affected by diphenylhydantoin, but it is not yet clear if this occurs in the liver or in the kidneys (Boyle 1974 Schaefer 1974, Apold 1976)

Fracture incidence in epileptics is high as expected, because of the nature of the disease (Table 1), but it is possible that antiepileptic therapy with diphenylhydantoin and the resultant osteomalacia cause an increase in frequency Several reports on material comprising smaller numbers of patients have indicated that treatment with vitamin D can have a beneficial effect on osteomalacia in epileptic patients on diphenylhydantoin (Christiansen et al 1973 a, b, Christiansen & Rodbo 1974, Latorre & Kenny 1974 Christiansen et al 1975 a, b)

In 87 patients on diphenylhydantoin we found a significant increase in the incidence of non-seizure-related fractures in particular cervical and trochanteric fractures of the femur (Tables 4 and 5), and ankle fractures (Table 6), as compared with the expected incidence in a normal population In the 7-year period the frequency of occurrence of non-seizure-related fractures in the 87 epileptics was six times that in the normal population (nine times for the men and four times for the women) (Tables 2–6)

When the epileptics are grouped according to age, the significant increase in fracture incidence is found within the 45 64 age group (Figure 1) This indicates that epileptics are not only more prone to fractures, but also have an earlier fracture début

Our present study represents part of a larger survey undertaken to relate fracture-proneness to the morphology and blood chemistry of epileptics in an effort to establish a basis for preventive treatment

MATERIAL AND METHODS

Consecutive unselected cases of osteoarticular tuberculosis who could provide an aspirable tuberculous material in the form of a tuberculous joint effusion or a cold abscess were included in this study. During preliminary work, a material of diseased osseous tissue granulation tissue and sequestra obtained from patients undergoing direct surgery for diagnostic or therapeutic purposes was also collected. However, this was later excluded from the present report because of frequent mixing with blood and a lack of control of the time interval for collection of the samples. Cases with doubtful diagnosis and with gross secondary infection were also excluded. Thus for the final assessment material from 79 cases was available.

The age of the patients varied between 8 months and 60 years; there were 38 males and 41 females. The disease in all the patients was active and well established. Fourteen patients had tuberculosis of joints (Group I), 13 knee joints and one elbow. Group II consisted of 65 patients who provided material from an ilio-psoas abscess in 34 cases and a cold abscess in other parts of the body in 31 cases. One of these patients provided 2 samples from cold abscesses in the arm and thigh. The majority of the patients showed varying degrees of tubercular cachexia and haemoglobin concentration on an average was 10 g per cent.

Administration of drugs and aspiration of material

The patients were weighed and were administered streptomycin sulphate intramuscularly in doses of 25 mg per kg of body weight (not exceeding one g) well away from the site of proposed aspiration. Ethambutol hydrochloride 25 mg per kg of body weight was given by mouth on an empty stomach. The drugs were administered for 2 consecutive days and on the second day, 3 hours after the administration blood and tuberculous material were aspirated under aseptic conditions. Special care was taken to avoid mixing of blood with the tuberculous aspirate.

Assay of the drugs

The broth dilution microbiological bioassay technique (Holmar et al. 19(9) was used for estimating the concentration of streptomycin in serum and the aspirate. For ethambutol a chemical assay technique was employed (Allen & Baker 1965).

Reassessment

After the first investigation the patients were put on the standard triple drug therapy consisting of streptomycin INH and ethambutol/PAS. Four patients from Group II provided the aspirable material for re-analysis 3 to 5 months after the onset of their treatment.

RESULTS

Observations regarding concentration of drugs in the joint aspirate and serum in Group I are summarised in Table 1, and

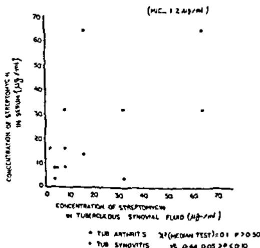


Figure 1. Correlation between the concentration of streptomycin in serum and in tuberculous synovial fluid (Group I)

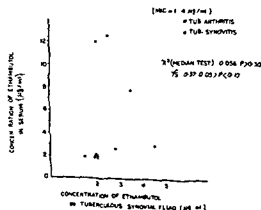


Figure 2. Correlation between the concentration of ethambutol in serum and in tuberculous synovial fluid (Group I)

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PENETRATION OF ANTITUBERCULAR DRUGS IN CLINICAL OSTEOARTICULAR TUBERCULAR LESIONS

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In 79 consecutive cases of skeletal tuberculosis the concentration o streptomycin and ethambutol was analysed The material for analys was obtained from the diseased joints of 14 patients and from col abscesses from spinal or osseous lesions in 65 patients The concentra tion of the drugs in the serum and in the tuberculous material wa measured 3 hours after the systemic administration of the drugs i therapeutic doses The concentration was expressed as μg per ml of th tuberculous material and the data were subjected to statistical analysis Streptomycin and ethambutol penetrated freely into the tuberculous joints, their concentration in the cold abscesses, however was half to one third of the concentration in the serum There was a wide range of concentrations, however, in the tuberculous joints as well as in the cold abscesses the concentrations were much higher than those con sidered to have an inhibitory effect on mycobacterium tuberculosis in clinical material

Key words antitubercular drugs, osteoarticular tuberculosis drug penetration ethambutol, streptomycin

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It has long been presumed that anti-tubercular drugs do not reach osteo-articular tuberculous lesions in adequate concentrations, and universal radical excisional surgery has been practised and advocated by many workers to ensure penetration of the drug into skeletal tuberculous lesions In recent times, however, a few clinical reports, especially from the developing countries, have been published, proving the efficacy of anti-tubercular drugs The quality, rapidity, consistency and durability of healing in clinical material led many workers to infer that the drugs were indeed reaching the site of infection (Lindberg 1967, Friedman & Kapur 1973, Medical Research Council 1973, Tuli 1975) To resolve the controversy regarding the power of penetration of anti-tuberculous drugs an experimental study was reported in 1974 by the senior author proving the easy accessibility of the experimental osseous tuberculous lesions to streptomycin (Tuli et al 1974) The present study was undertaken to determine the concentration of streptomycin and ethambutol in clinical osteoarticular tuberculous lesions

Concentration of streptomycin in serum

In Group I and Group II the range of concentration was 3 5-64 0 μg per ml Statistically the range in both groups was almost equal, the average concentration, however, was 23 34 μg per ml in Group I and 13 47 μg per ml in Group II This difference between the two groups, though statistically insignificant (median = 8, x^2 = 2 41, $P > 0\ 10$) may be explained on the basis of the relatively better general condition of the patients in Group I

Concentration of streptomycin in joint aspirate

The concentration in the joint aspirate was observed to be almost equal to that of the serum (median = 16, x^2 = 0 1, $P > 0\ 50$) meaning that streptomycin flows freely from the serum into the joint without any functioning barrier

Concentration of streptomycin in cold abscess

The range of concentration in 66 samples was 0 5 32 0 μg per ml, with an average of 6 03 μg per ml and median concentration of 4 0 μg per ml It was observed that there was a significant difference between the serum and pus concentrations (median = 8, x^2 = 5 23, $P < 0\ 05$) Spearman s rank correlation coefficient (rs = 0 72 $P < 0\ 001$) suggested a strong correlation, i e, with higher serum concentration there was a corresponding rise in the concentration in the abscess In general the concentration in the cold abscess was one third of that in the serum

Concentration of ethambutol in serum

The concentration in Group I ranged between 1 0 12 5 μg per ml with an average of 4 51 μg per ml In Group II the range was 3 0 16 0 μg per ml and average 10 17 μg per ml There was no statistically significant difference between the concentrations of Group I and Group II (medium = 12, x^2 = 1 13, $P > 0\ 20$)

Concentration of ethambutol in joint aspirate

The average concentration in tubercular joint aspirate was almost equal to the concentration in the serum (median = 2, x^2 = 0 05, $P > 0\ 30$) Like streptomycin ethambutol also appeared to penetrate freely into the tuberculous joints

Concentration of ethambutol in cold abscess

The concentration of ethambutol in the cold abscess was almost one third of the concentration in the serum The difference was statistically significant (median = 8, x^2 = 57 96 $P < 0\ 001$) Spearman's rank correlation between the serum and abscess concentration was statistically significant (rs = 0 28, $P < 0\ 05$) suggesting that the higher the concentration of ethambutol in serum the higher would be the concentration in the cold abscess

Reassessment after 3 to 5 months of triple drug therapy

In 4 patients in whom the concentration of drugs was reassessed, no significant change in the pattern of concentration was observed as compared with the pretreatment levels

DISCUSSION

In the human clinical material there are a large number of variables such as site, duration extent and pathological state of the lesion age, nutritional status, metabolic behaviour of the patient, previous treatment, sensitivity and type of infecting organism Earlier workers (Fellander et al 1952, Katayama et al 1954, Friedman & Kapur 1973) who tried to determine the concentration of streptomycin in tuberculous material in

Table 1 Concentration of streptomycin and ethambutol in serum and tuberculous joint aspirate (µg/ml)

Drug	Sample	No of cases	No estimated	Range of concentration	Average concentration	Median concentration
Streptomycin	Serum	14	13	3 5–64 0	23 34	16 0
	Joint aspirate	14	14	3 5–64 0	19 21	8 0
Ethambutol	Serum	14	11	1 9–12 5	4 51	2 0
	Joint aspirate	14	12	1 5–14 2	3 41	2 0

Table 2 Concentration of streptomycin and ethambutol in serum and cold abscess (µg/ml)

Drug	Sample	No of cases	No estimated	Range of concentration	Average concentration	Median concentration
Streptomycin	Serum	65	52	1 0–64 0	13 47	8 0
	Cold abscess	66	55	0 5–32 0	6 03	4 0
Ethambutol	Serum	65	53	3 0–16 0	10 17	12 0
	Cold abscess	66	50	1 3–10 5	3 21	2 5

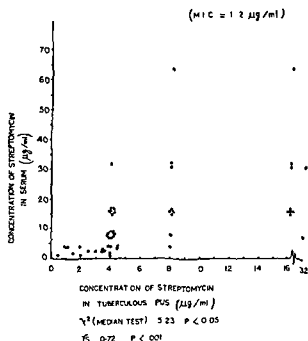


Figure 3 Correlation between the concentration of streptomycin in serum and in tuberculous cold abscess (Group II)

Figures 1 and 2 The corresponding observations in Group II (66 samples from 65 patients) are shown in Table 2, and Figures 3 and 4

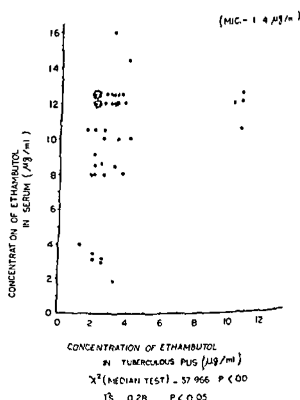


Figure 4 Correlation between the concentration of ethambutol in serum and in tuberculous cold abscess (Group II)

Concentration of streptomycin in serum

In Group I and Group II the range of concentration was 3 5 64 0 μg per ml Statistically the range in both groups was almost equal, the average concentration however, was 23 34 μg per ml in Group I and 13 47 μg per ml in Group II This difference between the two groups, though statistically insignificant (median = 8, x^2 = 2 41, $P > 0\ 10$) may be explained on the basis of the relatively better general condition of the patients in Group I

Concentration of streptomycin in joint aspirate

The concentration in the joint aspirate was observed to be almost equal to that of the serum (median = 16, x^2 = 0 1, $P > 0\ 50$) meaning that streptomycin flows freely from the serum into the joint without any functioning barrier

Concentration of streptomycin in cold abscess

The range of concentration in 66 samples was 0 5 32 0 μg per ml, with an average of 6 03 μg per ml and median concentration of 4 0 μg per ml It was observed that there was a significant difference between the serum and pus concentrations (median = 8, x^2 = 5 23 $P < 0\ 05$) Spearman's rank correlation coefficient (rs = 0 72, $P < 0\ 001$) suggested a strong correlation i e, with higher serum concentration there was a corresponding rise in the concentration in the abscess In general the concentration in the cold abscess was one third of that in the serum

Concentration of ethambutol in serum

The concentration in Group I ranged between 1 9 12 5 μg per ml with an average of 4 51 μg per ml In Group II the range was 3 0 16 0 μg per ml and average 10 17 μg per ml There was no statistically significant difference between the concentrations of Group I and Group II (medium = 12, x^2 = 1 13, $P > 0\ 20$)

Concentration of ethambutol in joint aspirate

The average concentration in tubercular joint aspirate was almost equal to the concentration in the serum (median = 2, x^2 = 0 05, $P > 0\ 30$) Like streptomycin ethambutol also appeared to penetrate freely into the tuberculous joints

Concentration of ethambutol in cold abscess

The concentration of ethambutol in the cold abscess was almost one third of the concentration in the serum The difference was statistically significant (median = 8, x^2 = 57 96, $P < 0\ 001$) Spearman's rank correlation between the serum and abscess concentration was statistically significant (rs = 0 28, $P < 0\ 05$) suggesting that the higher the concentration of ethambutol in serum the higher would be the concentration in the cold abscess

Reassessment after 3 to 5 months of triple drug therapy

In 4 patients in whom the concentration of drugs was reassessed, no significant change in the pattern of concentration was observed as compared with the pretreatment levels

DISCUSSION

In the human clinical material there are a large number of variables such as site, duration, extent and pathological state of the lesion, age, nutritional status metabolic behaviour of the patient, previous treatment, sensitivity and type of infecting organism Earlier workers (Fellander et al 1952, Katayama et al 1954, Friedman & Kapur 1973) who tried to determine the concentration of streptomycin in tuberculous material in

human skeletal tuberculous lesions observed a wide variation in their results from patient to patient Similar variations were observed in our study and that is why the data have been statistically analysed for clinical application and the range of concentrations has been mentioned

Streptomycin concentration in the serum

Streptomycin does not penetrate the erythrocytes, therefore its concentration is approximately twice that in whole blood The average serum concentration reported by various workers (Katayama et al 1954, Barry 1964, Friedman & Kapur 1973) 3 hours after intramuscular injection of 1 g of streptomycin is estimated to range between 20 and 30 μg per ml approximately The average serum concentration in our study was 23 34 and 13 47 μg per ml, in Group I and II, respectively Overall comparison with other reports reveals similar concentrations in different races

Streptomycin concentration in tuberculous material

Barry (1964) measured that almost 50 to 80 per cent of any drug would reach a tuberculous joint from the blood Observations in the present report confirm this belief that streptomycin penetrates freely into the intra-articular compartments The difference between the serum and joint concentrations in our study was statistically insignificant (median = 16, $x^2 = 0\ 1$, $P > 0\ 50$)

In the cold abscess, Katayama et al (1954) measured 2 7 μg per ml of streptomycin 1½ hours after the administration of ½ g of streptomycin Fellander et al (1952) and Hever & Risko (1960) observed 2 4 μg of streptomycin 3 hours after the administration of 1 g of streptomycin In the present series, although there was a wide variation in range (0 5-32 0 μg per ml), in the majority of the patients the concentration achieved in the abscess was much higher than the minimum inhibitory concentration (MIC) required for most types of human mycobacteria (MIC for most of Mycobacteria hominis = 1 μg per ml)

Ethambutol concentration in serum

After oral administration, this drug is readily absorbed and most of the drug circulates accumulated on the surface of the erythrocytes It is rapidly excreted through the kidneys Accumulation on the erythrocytes means that the concentration in the serum is almost half that of the whole blood Most workers (Bobrowitz 1966, Donomae & Yamamoto 1966 Gomez-Pimienta et al 1966, Pyle et al 1966) have reported the ethambutol concentration in the serum to range between 3 and 6 μg per ml under almost similar conditions The concentration in the serum in the two groups in our series ranged from 1 2 to 16 0 μg per ml

Ethambutol concentration in tuberculous material

Like streptomycin the average concentration of ethambutol in the joint aspirates (Group I, 3 41 μg per ml) was the same as that of the serum (median = 2, $x^2 = 0\ 05$, $P > 0\ 30$) thus suggesting free flow of the drug into the tuberculous joints

In Group II, on the other hand, the concentration in the cold abscess (3 21 μg per ml) was about one third of the concentration in the serum (10 17 μg per ml) We could not obtain observations of other workers The minimum inhibitory concentration of ethambutol for all varieties of mycobacteria is reported to be 1 4 μg per ml of the fluid, though most of the mycobacteria from human clinical tuberculous material are susceptible to 1 μg per ml of ethambutol (Lucchesi et al 1966) Thus, even in Group II, the concentration of ethambutol in the

tuberculous pus was much higher than the required minimum inhibitory concentration of ethambutol for the infecting organisms The majority of the skeletal tuberculous lesions are caused by the human type of mycobacteria which are expected to respond to concentrations of 1μg of ethambutol per ml

Reports of other workers

It has been shown by various workers that radioactive dihydrostreptomycin (Andre 1956 Hanngren & Andre 1964 Lindberg 1967) and radioactive para aminosalicylic acid (Hanngren 1959) reach skeletal tubercular foci Radioactive isoniazid (Barclay et al 1953, Canetti 1955) has been reported to diffuse freely into all tissues including bone as well as into abscess cavities and even dried caseous material, in sufficient concentrations to destroy the bacteria Tuli et al (1974) reported that the concentration of streptomycin in experimental osseous tuberculous lesions after a single intramuscular injection (equivalent to a therapeutic dose) was much higher than that considered inhibitory to the human type of mycobacterium tuberculosis

Therapy in clinical cases

In clinical practice as a rule more than one drug is administered over a period of time Isoniazid the most commonly used drug has the property of causing vasodilation in the diseased area Thus it may rationally be expected that the titre of concentration of the individual drugs would be much higher and the cumulative bacteriostatic/bacteriocidal effect would be much greater than that observed after limited doses of the drugs It is clear that irrespective of the precise pharmacodynamics in clinical practice the concentrations achieved in skeletal tubercular lesions are in excess of the usually accepted inhibitory levels of the drugs to the mycobacterial organisms It can be stated with certainty that if the organism is sensitive to the antitubercular drug and the drug is administered for a sufficient period of time the infection may well be controlled and most of the lesions will heal If a lesion does not come under control the cause is not failure of the drugs to reach the lesion in sufficient concentrations The cause lies in other factors such as the nature of the mycobacterium (atypical, being generally resistant to first line drugs), the resistance of the infecting organism to the drugs being administered and the mechanical nature of the pathology of the skeletal lesion, e g the presence of a large sequestra and areas of extensive destruction

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ISOLATED DISLOCATION OF THE CARPAL SCAPHOID

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A case of isolated dislocation of the carpal scaphoid is presented and the literature on the subject reviewed An analysis has been made of the cases reported and attention is drawn to certain features which are c mmon t m st f the cases

Key words scaphoid carpal d slocation isolated

Accepted 8 iii 77

With the exception of the lunate bone an isolated dislocation i e a dislocation un *associated with displacement or fracture* of other carpal bones is extremely rare and that of the scaphoid is no exception It receives but scant attention in many standard textbooks and none at all in others Nigst & Buck Gramcko (1975) in their classification of the types of subluxations and luxations of the carpal scaphoid draw attention to its radiolog ical features but a search of the litera ture reveals that since 1930 only eight cases have been reported two by Higgs (1930) one each by Buzby (1934) Kuth (1939) Walker (1943) Russell (1949) Schlosshach (1954) Connell & Dyson 1955) By contrast the other and en tirely unrelated type of displacement of the scaphoid that known as rotational subluxation (or dislocation) has been abundantly documented during the same period

The rarity of isolated dislocation sometimes referred to as acute disloca tion of the scaphoid merits a report of a further case thus making a total of nine in the last 46 years

CASE REPORT

A 23 year-old driver of a car was involved in a road accident in February 1976 damag ng his right wrist When seen at the hospital within an hour of the accident his wrist was painful movements were restricted and there was an ab normal tender bony prominence distal to th radial styl id process There was no *nerve* lesion There was a slight general swelling

X rays (Figure 1) showed that the scaphoid was dislocated forward and outward but there was no evidence of displacement or fracture of the other carpal bones There was a fracture at the base of the styloid process of the ulna Under general anaesthesia reduction was easily achieved by traction on the thumb and fingers and digital pressure on the bony pr minence— the bone sl pping back into position with a soft snap Subsequent X rays (*Figure 2*) showed that the bone had been fully reduced

The wrist was immobilised in slight dorsi flexion in plaster for 6 weeks He was then en couraged to put the hand to increasing use He resumed his normal work as a teacher of pottery in 8 weeks E ght months after the *injury he had* no complaints except an occasi nal ache and was doing his n rmal work without difficulty There had been n recurrence of the dislocation The wrist was normal in appearance and in movements X rays (Figure 3) showed no evid ence of ischaem c *necrosis* nor of any other ab normality



Figure 1 Initial displacement of the scaphoid



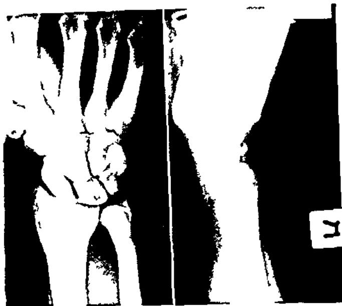
Figure 2 Full reduction

DISCUSSION

A study of the reports of the eight published cases, together with the one reported here, reveals certain features which are common to the majority who have suffered this injury

The mechanism In all but one case (Schlossbach 1954) the injury resulted from accidents involving road vehicles

Figure 3 Normal appearances 8 months after the injury



Thus five were sustained whilst riding a motor cycle two whilst driving a car and one on cranking an engine A factor which is common to all these activities is that the wrist is firmly held in a position of dorsiflexion and ulnar deviation A sudden violent jerk forcing the hand further in these two directions would have a distraction effect on the radial aspect of the wrist joint and eject the scaphoid in a forward and outward direction This is the position with slight variation which is seen in the X rays of the majority of the cases This mechanism suggested by Connell & Dyson (1955) is confirmed by a study of these cases As a point of interest all reported cases have been men

Diagnosis and treatment With one exception all the patients were seen early usually within hours of the accident and the diagnosis presented no difficulty either by clinical examination alone or by X rays and there was no delay in instituting treatment Closed reduction was easily accomplished by traction on the fingers and digital pressure on the bony prominence followed by immobilisation for a few weeks with the wrist in slight dorsiflexion

Open reduction was very rarely called for when the patients were treated promptly but it became necessary in two cases thus Higgs (1930) described how open reduction had to be employed in one of his cases first seen 6 weeks after the injury Walker (1943) in a case presenting 5 days after the injury failed to reduce by manipulation and even at operation the bone could not be restored to its normal position He removed it excised some obstructive tissue and was then able to replace it easily and it remained stable

Ischaemic necrosis A remarkable feature in view of the gross displacement of the bone is that this complication is not reported as having occurred in any of the patients Even in the case described by Walker (1943) and referred to above although the X ray appearances 7 weeks after the operation showed changes suggestive of ischaemia of the scaphoid 7 months later the bone was normal

Results The results in all nine cases

whether reduced by closed or open methods, were uniformly good although not necessarily perfect None suffered from subsequent instability No doubt such good results are to be attributed to their being seen and diagnosed early and easily (in contrast to many cases of rotational subluxation) and the fact that at this early stage closed reduction is readily accomplished

ACKNOWLEDGEMENT

I wish to thank Mr C J F Monk F R C S M Ch Orth, for his kind permission to report this case

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SOME ASPECTS OF BONE GRAFTING FOR NON-UNION OF THE CARPAL NAVICULAR

Analysis of 41 Cases

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Forty one patients with established non union of the carpal navicular are presented Forty patients were treated by bone grafting using the same operative technique in all of them All operated fractures healed and were free of pain at the time of union Vascularization did not seem to interfere with union in the different types of fractures Radial styloidectomy performed in addition to bone grafting in 26 of the patients who had arthritic changes improved their wrist mobility

Key words carpal navicular bone grafting non union

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There are different points of view concerning open reduction and bone grafting (Gasser 1965 Gordon & King 1961 Graner et al 1966 Milford 1963 Torngren & Sadqvist 1974 Waugh & Reveling 1965) Most authors are rather reluctant to use this procedure for long standing non union with arthritic changes in the wrist joint or fractures involving the upper third of the navicular (Boehler et al 1954 Gasser 1965 Kessler et al 1963 Scholder 1963) In view of this we present our experience with 40 cases of established non union of the carpal navicular treated by bone grafting

MATERIAL AND METHODS

Forty one patients with non union of the carpal navicular were examined Forty had open reduction and bone grafting performed and were followed until union was confirmed and wrist motion restored One patient with a 22 year old ununited fracture with no pain and no radial abduction was not operated on (see Discussion) The age of the patients varied between 16 and 32 years with an average age of 24 All of them were healthy normal males

All patients except for one had a history of a minimum of 1 year of painful limitation of wrist motion affecting daily activity following fracture of the navicular bone Radiologically there was definite evidence of non union of a fractured scaphoid with signs of necrosis of a fragment in 23 of the patients and arthritic changes around the fracture site in 34 Twenty six fractures were horizontal oblique of the mid third of the bone (Russe 1960) six being displaced Ten were fractures of the proximal third four of which were displaced fractures of the lower third of the bone

The operative technique was that of Russe (1960) In some cases an additional radial styloidectomy was performed After surgery an above-elbow circular cast was applied for 6 weeks

The postoperative management was the same in all patients the cast was removed after 6 weeks and X rays were taken prior to the application of below elbow immobilization The

whether reduced by closed or open methods, were uniformly good although not necessarily perfect None suffered from subsequent instability No doubt such good results are to be attributed to their being seen and diagnosed early and easily (in contrast to many cases of rotational subluxation) and the fact that at this early stage closed reduction is readily accomplished

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prior to surgery varied from 1 to 13 years The duration of the non union did not affect the final results as far as pain and subsequent union were concerned In long standing cases (Figures 1 2) the ultimate result was not influenced by the arthritis which had developed around the radio-navicular joint during this long period However our study demonstrates that unlike pain or successful union the improvement of mobility following surgery was related to the preoperative duration of non union Hence the post operative mobility of the wrist increased in all 23 cases with 18 months or less of non union while only four of the 17 patients with more than 18 months of non union showed improved mobility

Vascularization and consolidation

According to Bunnell (1964) the most important reasons for non union of a fracture are excessive mobility at the fracture site and deficiency of the blood supply According to Boehler (1954) non union will occur in about 10 per cent of all fresh cases even with adequate plaster of paris immobilization and satisfactory blood supply to the



Figure 3 Injected specimen in Spalteholz volar aspect radio-carpal joint Anastomoses between radial and anterior interosseous arteries showing branches to the proximal areas of the navicular and lunate bones (Illerness & Lewis ... preparation)



Figure 4 Five year old ununited and untreated fracture of the middle third of the navicular before surgery

fractured fragments Kessler (1963) maintains that marked displacement of fragments interposition of soft tissues and incorrect treatment are the factors responsible for non union and not the vascular insufficiency In 100 cases of bone grafted scaphoides Murray (1946) reported a 40 per cent incidence of preoperative aseptic necrosis and yet all healed following surgery Trueta (1968) reviewing injected carpal naviculars found the proximal half of the bone to be supplied by some little arterioles "scattered about" It was evident to him that slowness of union of a fracture across the neck of the navicular is due to the poor blood supply to the proximal fragment Taleisnik et al (1966) demonstrate in their anatomical study of the carpal navicular vascular anatomy that three branches of the radial artery penetrate the bone from three different

casts were changed and X-rays taken every 6 weeks until union was confirmed. When X-ray results were doubtful, tomography was performed.

RESULTS

The shortest period of immobilization was 6 weeks, the longest 10 months with an average of four and a half months. All fractures healed with bone grafting and all patients were free of pain at the time of union regardless of the duration of non-union or the type of fracture. The postoperative mobility was improved in more than half of the cases (24) compared to the preoperative range of motion, and most of the patients returned to their original occupation.

In 26 patients, radial styloidectomy was performed at the time of bone grafting. Indications for this additional procedure were: Painful limitation of radial abduction, radiological evidence of narrowing of the radio-navicular space, and local arthritic changes around the radial styloid. Increased mobility, after this treatment, was observed in 13 of the 26 patients, mobility remained unchanged in four and was reduced in nine. All 23 cases with 18 months or less of non-union increased their wrist mobility after surgery, while only four of the 17 patients with more than 18 months of non-union showed improved mobility.

DISCUSSION

Duration of non-union

The term 'non union' of a fracture is time related. Experience shows that prolonged immobilization decreases the incidence of non-union. Certain authors (Boyes 1964) require a minimal period of 3 months, others (McKim 1944), more than 9 months. However prolonged immobilization may be damaging to joint mobility and to muscle power.

In our study of non-union, the period



Figure 1. Thirteen year old non union following failed bone grafting procedure with radio ulnar styloidectomies.



Figure 2. Same case as Figure 1 after second bone grafting procedure. Healing occurred after 7 months of immobilization.

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Figure 4 Five year old ununited and untreated fracture of the mid third of the navicular before surgery



Figure 5 Injected specimen in Spalteholz volar aspect radio-carpal joint. Anastomosis between radial and anterior interosseous arteries showing branches to the proximal areas of the navicular and lunate bones (Herness & Le Winn in preparation)

directions; a lateral volar vessel, at the radial articular surface; a dorsal branch, in the area of the insertion of the dorsal radio-carpal ligament, and a more distal branch at the insertion of the lateral radio-carpal ligament A proximal vessel was also seen in one of the 11 specimens studied.

Our own radio-anatomical studies of injected specimens support the findings of Logroscino & DeMachi (1938), Scholder (1953) and Travagline (1959) of the direct participation of the volar and dorsal interosseous arteries in supplying the proximal areas of the navicular and lunate bones (Herness & Le Winn, in preparation), in addition to the radial artery vascular supply (Figure 3). These various studies show that the proximal, mid, and distal thirds of the bone each has its own source of blood. Hence, vascularization of the separated fragments of the fractured bone is only rarely interrupted in most types of fractures Thus, 5 year old, untreated and ununited fractures of the mid-third of the bone with a theoretically adequate blood supply



Figure 6 One year old untreated fracture of the proximal third of the navicular



Figure 5 Same case as Figure 4 after bone grafting Healing occurred after 4 months of immobilization.



Figure 7 Same case as Figure 6 following bone grafting Union occurred after 4 months of immobilization

(Russe 1960), necessitated the same im mobilization time following surgery as 12 month old fractures of the proximal third with a supposedly poor vascular supply (Figures 4 5 6 7) of the prox imal fragment (Russe 1960) This im plies that the graft acts as a bridge or a vascular short cut (Boyes 1964) for regenerating bone formation between the separated fragments

Styloi lectomy

Arthritic changes around the radio navicular joint so often seen in radiog raphies of wrists with ununited frac ture of navicular bone are due to changes in the joint stability This seems to be caused primarily by the displaced and unstable fragments of the fractured nav icular bone which cause an abnormal motion at the radio navicular joint (Gras 1959) Limitation of motion at the radio navicular joint especially radial abduc tion is progressive and causes pain Hence arthritis with pain and limitation of motion will continue to progress until the fracture is united Simple styloidec tomy will probably not resolve these mutually dependent developments and may even interfere with the natural course of healing In fact it may further deteriorate wrist mobility However styloidectomy combined with bone graft

cases The first one shows the natural course of an untreated fracture A 22 year old ununited displaced fracture of the upper third of the right navicular was discovered accidentally in a patient seen for other reasons On examination the patient had no radial abduction of the wrist X rays of the wrist showed in addition to the fracture marked arthritic changes with narrowing of the radio navicular joint and calcifications along the lateral collateral ligament (Figure 8 The patient reported that pain had



Figure 8 Twenty two year old ununited dis placed fracture of the nav cular Marked arthritic changes around the fracture site and the radio nav cular joint Arrow poi ts to calcificat on along the lateral collateral l gament

decreased over the years as limitation of radial abduction developed and it had subsided 10 years previously when this motion was entirely abolished

The second patient (Figure 1) was seen for increasingly severe pain and progressive limitation of motion follow ing an unsuccessful bone grafting of an ununited fracture of the navicular bone with ulnar and radial styloidectomies performed elsewhere This can be ex plained by the increased mobility at the fracture site caused by the styloidec tomies Following a second bone graft the fracture united, the pain subsided and the motion improved (Figure 2)

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MADELUNG'S DEFORMITY

A Follow-up Study of 26 Cases and a Review of the Literature

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Madelung's deformity, the history, aetiology, pathogenesis and prognosis, is discussed, on the basis of the literature The author's material of 26 cases has been followed up Thirteen of them were treated by resection of the ulna head or shortening of the ulna with or without wedge osteotomy of the radius The result was an improvement in pain and a cosmetic improvement but mobility was unaltered Spontaneous improvement in the symptoms is common, so that a waiting policy, and observation of the patient until growth ceases, is recommended

Key words deformity of the wrist, dysplasia of bone, dyschondrosteosis, epiphysis growth, Léri Weill syndrome, Madelung's deformity

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In 1878, O Madelung described a severely deformed wrist in a young woman According to Madelung, this *spontaneous forward subluxation of the hand* (Figure 1) had already been described (Dupuytren 1834, Malgaigne 1855, Weber 1859, Nélaton 1847) and Madelung himself had at that time seen 12 cases Madelung considered that the deformity was due to a disturbance of the growth of the joint the result of overloading a joint already predisposed to malformation The prognosis was good and Madelung advocated the term *manus valga* for the condition Since then, the topic has fascinated numerous investigators, not least Scandinavians (Poulsen 1904, Natvig 1905, Solberg 1906, Björkroth 1932, Paus 1941, 1951 Bergan 1942, Schulstad 1971), and it was Poulsen (1904) who showed that Malgaigne and not Dupuytren should receive the honour of reporting the first



Figure 1 Illustration from Madelung's original study

case of Madelung's deformity (MD) Since then there h [illegible] as [illegible] re- [illegible] nal picture of the disease has been widened and has become increasingly difficult to define, as evidenced by the 33 synonyms which can be encountered in the literature

In the years 1929 and 1931, Léri & Weill and Léri et al published two cases of genetic dwarfism called dyschondrosteosis, where MD was one of the charac-

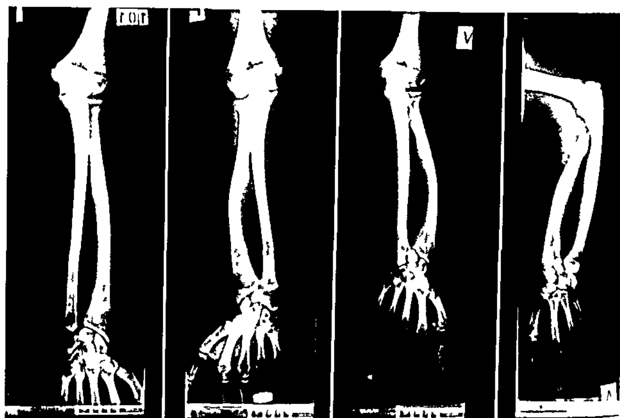


Figure 2 X rays of the forearm in four different patients with Madelung's deformity showing an increasing degree of severity from left to right The patient on the right shows a malformation of the head of the radius which is never observed in patients with genuine Madelung's deformity

teristic features As a consequence of this, several authors have regarded these two diseases as being identical (Herdman et al 1966), whereas others have clearly distinguished between them (Felmann & Kirkpatrick 1969) Symptomatic cases have also been described simulating Madelung's *spontaneous* subluxation traumatic, neoplastic or infectious (Stetten 1909, Bjorkroth 1932, Anton et al 1938, Stypa 1973), hormonal, biochemical or genetic disturbances (Thompson & Kalayjian 1939, Henry & Thorburn 1967) or in generalized dysplasia of bone (Table 1) (Nassif & Harboyan 1970, Nielsen & Galatius-Jensen 1971) According to Kelikian (1974) seven cases of reversed MD have been described

It is maintained nowadays that MD is a genetic disorder found more frequently in women than in men, twice as frequently bilaterally and then often with the same degree of severity on both sides The condition is localized to the distal epiphysis of the radius, which shows failure of growth, most often in the ulnar/volar portion Clinically, it appears during the growth period with functional pain and troublesome prominence of the ulnar head, apparent subluxation of the wrist, and curvation and possible shortening of the forearm The deformity varies from quite mild symptomless forms to cases of more severe invalidism (Figure 2)

Table 1 Types of bone dysplasia associated with Madelung's deformity

Dyschondrosteosis
Achondroplasia
Multiple exostoses
Multiple epiphyseal dysplasia
Dyschondroplasia (Ollier)

Madelung advised conservative treatment, and Poulsen (1904) reports that

Table 2. Sex distribution and age of onset of the 26 patients with Madelung's deformity (MD) grouped according to the classification of Table 1. The table shows the number of patients operated on, the cases with familial disposition and the stature at follow-up examination

Classification		No of pts	♀	♂	Age of onset	No of ops	Familial disp	Stature at follow up examination
Idiopathic MD	Genuine	13	13	0	6–15 (10½)	7**	2	157–172 cm (165 cm)
	Dysplasia*	10	9	1	11–16 (13)	5**	6	137–156 cm (150 cm)
Symptomatic MD		3	0	3	–	1	–	170–188 cm (180 cm)
Total		26	22	4	–	13	8	–

* 9 cases of dyschondrosteosis + 1 case of multiple exostoses

** 1 patient in each group underwent operation on both sides (a total of 15 operations)

surgical intervention with tenotomy of the "contracted" flexors by the method of Busch (1864) was soon abandoned. The first osteotomy of the curved radius for MD was performed by Duplay (1885). Numerous surgical procedures have been recommended in which either the deformity of the radius was attacked or that of the relatively elongated ulna; in some cases both were treated (Poulsen 1904, Stetten 1909, Darrach 1913, Burrows 1937, Kelikian 1974).

PATIENTS AND METHODS

A total of 26 patients (22 women and 4 men) with MD attended the Department of Surgery of the Hand, Orthopaedic Hospital, Copenhagen, during the years 1954 to 1974. The symptoms were pain and restricted movement of the wrist which had their onset in the age group 6 to 16 years. Familial disposition was frequently encountered. Patients with bone dysplasia were short in stature (Table 2). MD coincided with other deformities: various exostoses, bone cysts, short fourth metacarpal, sacralisation and double kidney in six out of the nine patients with dyschondrosteosis. This has also been found by other authors (Henry & Thorburn 1967, Nassif & Harboyan 1970, Solberg 1906, Stetten 1909, Kelikian 1974, Nagura 1971).

In half of the patients the symptoms were so pronounced that operation was indicated. The operated patients were between 14 and 57 years of age (average 22 years). Table 3 shows the operations employed.

Table 3. Fifteen operations for Madelung's deformity in 13 patients

	No of wrists
Excision of the head of the ulna	4
Excision of the head of the ulna + wedge osteotomy of the radius	4
Shortening of the ulna	2
Shortening of the ulna + wedge osteotomy of the radius	1
Resection in the distal ulna	1
Resection in the distal ulna + radio/ulnar arthrodesis distally	3
Total	15

In the case of excision of the head of the ulna a simple resection of the distal head was performed except for the styloid process, whose connection with the radius via the articular disc and via the collateral ligament to the carpal bones ensures stability of the wrist. Shortening of the ulna was performed as a Z-shaped shortening osteotomy of the distal ulna which was immobilized by means of a plate and screws. Resection of part of the distal ulna (removal of a segment of the shaft of the ulna one cm long, about one cm above the radio-ulnar joint distally) was performed to create a pseudarthrosis in order to permit free rotation in the forearm, especially in three severe cases.

Table 4 Follow up examination of 26 patients with Madelung's deformity (13 treated operatively)

		Results of follow up examination		
		Improved	Unchanged	Worse
A 13 patients operated on (7 MD, 5 D 1 SMD) **	Subjective Rotation	9 1 *	4 10	0 2
B 13 patients not operated (6 MD, 5 D, 2 SMD)	Subjective	7	4	2

* > 29° increased rotation in the forearm
** MD = Genuine Madelung's deformity, D = dysplasia, SMD = symptomatic Madelung's deformity
In Group A, 8 were working 4 were at home/school 1 had a disablement pension
In Group B, 6 were working, 5 were at home/school 2 had a disablement pension

where the radius had a very steep joint surface (Figure 2, last film) Here, radio ulnar arthrodesis was performed using a screw distally, to avoid ulnar dislocation of the carpus Of the other 12 wrists, the radius deformity was found to be so pronounced in six cases that in addition to one of the three surgical interventions on the ulna described above, a wedge osteotomy of the radius was performed, a radial skin incision being made and a sub periosteal wedge removed from the distal radius about two cm above the radio ulnar joint The base of the wedge was positioned more or less dorso radially depending on the steepness of the joint surface and the curvature of the radius The osteotomy was immobilized with *clamps, or bone or periosteal sutures Reoperation* was necessary in three cases in two of them the ulna was shortened, and in the third a radio ulnar re arthrodesis was performed

All patients in the group were followed up The operated patients were seen on an average 8 years and 6 months after the surgical intervention (from 6 months to 20 years)

RESULTS

The results are shown in *Table 4* Nine out of thirteen operated patients reported a subjective improvement of their *condition* in the form of reduced pains Four patients found their condition unchanged Physical examination showed that the mobility, especially rotation of the forearm, had been significantly *im*proved (i e more than 29°) in only *one* patient, in ten patients the mobility was generally unchanged and in two patients the *range of movement* had deteriorated

Table 5 Classification of Madelung's deformity

I) Idiopathic Madelung's deformity
  a) Classic genuine Madelung's deformity
  b) Dysplasia of bone + Madelung's deformity
II) Symptomatic Madelung's deformity (Pseudo Madelung's deformity)

DISCUSSION

The literature shows that numerous *classifications of a more or less compli*cated nature have been attempted, based either on morphology or on "aetiology" (Anton et al 1938, Henry & Thorburn 1967, Jaikaran 1969, Kelikian 1974 Matev & Karaganchева 1975) A new classification which fits in with the *material presented here* is shown in Table 5

All idiopathic deformities were found to be bilateral, often unequal, with a considerable preponderance of *symptoms* on one side This applied both to patients with genuine classic MD and to *patients with dyschondrosteosis* or some

other form of bone dysplasia, contrary to the findings of Matev & Karaganchева (1975) and other authors In both groups there was a familial occurrence of the disease (Table 2), but this was more common in the latter group More remarkable, however, is the fact that almost all patients in the group with idiopathic MD were women

Already in his studies Madelung was aware that most often the trouble appeared between the ages of 8 and 14 years, often progressing from initially mild functional pain to fatigue and loss of strength, and finally reduced mobility After some years the trouble often became stationary, and the pain decreased Due to this fact a certain period of observation was required in order to be able to reach a decision as to whether or not operation should be performed

The results show that on an average our patients were operated almost 10 years after onset of symptoms The reason was our decision to delay operation until termination of growth and closing of the epiphysis of the radius had occurred at the age of 18 to 20 years

Of the thirteen operated patients, nine felt that the operation had helped, they had less pain, better subjective function and a cosmetically more attractive wrist (Table 4) However, in only one patient was the mobility, especially rotation of the forearm, significantly improved It had remained more or less unchanged in ten patients, and had deteriorated in two patients The patient with improved rotation, however, did not experience any beneficial effect from the operation, while the two patients with more limited rotation postoperatively considered that the operation had been helpful This agrees with the observation that limitation of movement is not a serious complaint What the patients attach importance to and what leads them to seek medical help is the pain This was the case in 23 out of the 26 patients in question The last three patients sought treatment for cosmetic reasons due to the prominent head of the ulna

Based on this investigation, operation cannot be considered of any significant value as regards mobility, but the functional pain decreases and the strength is evaluated subjectively as having increased Ranawat et al (1957) found similar results Only a minority of patients require operation

We have adopted an attitude of reserve, and a longer period of observation is required, at least during the period of growth, before surgical intervention is decided upon and choice is made as to the method preferred

This material still provides no real aetiological explanation for MD, but some sort of "aetiological" classification as shown in Table 5 would seem rational and easy to grasp

Conclusion

On the basis of the literature and this material, a new classification of MD is recommended

Almost all patients included in the investigation with non traumatic MD are women, and a familial incidence is common

Because of a difference in the degree of severity, the complaint is often only one-sided Unilateral deformity was found only in patients with so-called traumatic MD The most severe cases are found in patients with other forms of bone dysplasia, especially dyschondrosteosis It is common to find spontaneous improvement in pain and in impaired strength at the end of the growth period Therefore a period of observation is recommended after closure of the epiphyseal line, before any decision is made to operate

No specific surgical method can be recommended The type of intervention must depend on the degree of severity of the deformity Only a minority of pa-

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PAGET'S SARCOMA OF THE VERTEBRAL COLUMN WITH NEUROLOGICAL COMPLICATIONS

F T SHANNON & J S HOPKINS

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A patient with Paget s sarcoma of the vertebral column who developed cauda equina compression is reported Th s is the first report of this condition in an orthopaedic journal The l terature is reviewed Palliative treatment is recommended

Key words complications osteitis deformans

Accepted 15 ıx 77

Spinal cord and cauda equina compression is a recognised complication of Paget s disease of the vertebral column (Hartman & Dohn 1966 Miller 1967 Siegelman et al 1968) One hundred and four such cases have been reported in the English literature Six of these had histological proof of sarcomatous change We report details of a further patient with sarcoma in Paget s disease of the vertebral column who developed paraparesis

CASE REPORT

In N vember 1973 I H a 58 year-old woman first complained f l w back pa n radiating to both iliac fossae In Jan iary 1974 she was ad m tted to the general medical ward because of miting and abd minal pains These complaints hanged within ? weeks to bilateral buttock pa n at wh ch time it was first noted that she had Paget s disea e f her lumbar spine and left hem pelvis she was a vis ed bed rest at home and a surg cal c rset su ppo rt In February 1974 he c mpla ned f pain in her right groin ra l at ng to all dermatomes f the right lower l mb with similar less severe pain in the left .

In March 1974 her pain w rsened and she rapidly developed bladder and bowel paresis leading to her admiss on to Harlow Wood Orthopaedic Hospital

On examinat on there was evidence of an incomplete parapleg a with an approximate sensory level at T_{12} There were no external features of Paget s d sease X rays again showed Paget s disease of L_2 and sclerosis of L_1 It now seemed that there was possibly some destruction of the right pedicle of L_1 Chest X ray was normal Myelography showed a complete block at L_1 level (Figure 1) with features of an extra dural compressive lesion on the right side CSF protein was 200 mg per cent

It was thought that the neurological condition might be due to structural narrowing of the spinal canal because of Paget s disease of L_1 and L_2 though tumour was considered

On the 20th of March 1974 a decompressive laminectomy from T_{12} to L_3 inclusive was performed The find ngs were of softened thickened vertebral arches at L_2 and L_3 levels narrow root canals at L level thickened dura in all upper lumbar levels but normal dura at L_4 and L_5 levels There was extensive haemorrhage from the bone during operation the blood loss totalling 2 100 ml No certain tumour t ssue was seen but specimens were taken from all levels Histology confirmed Paget s disease affecting all the arches from T_{12} to L_4 The specimens from the L_1 nerve root canals (the level of myodil block) revealed a cellular osteosarcoma on the right side with some infiltration at the edge on the left s de (Figure 2)

tients require surgical correction, and this rarely improves mobility to a significant degree, although it reduces pain, improves subjective function and results in a cosmetically more attractive wrist

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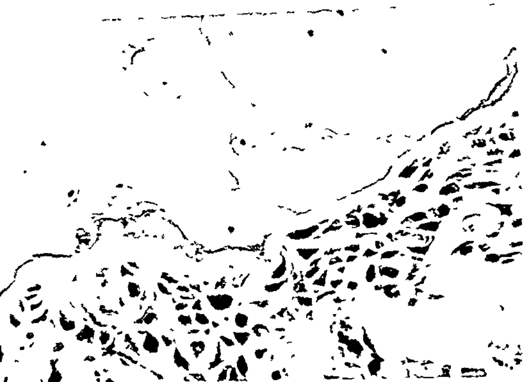


Figure 2 Paget's disease of bone with cement mosaic rimmed by malignant osteoblasts

column When treated by decompressive laminectomy a gratifying result may be expected (Hartman & Dohn 1966, Klenerman 1966, Miller 1967, Siegelman et al 1968, Direkse & Milnes 1970, Cartlidge et al 1972) Of the 104 cases so far reported, 69 had operative decompression and 58 had definite, though variable, relief of pain and neurological signs (Feldman & Seaman 1969, De Rose et al 1971, Cartlidge et al 1972, Sadar et al 1972, Melick et al 1976)

The true incidence of sarcomatous change in Paget's disease remains uncertain When it occurs the sites commonly involved are the femur, pelvis, humerus and skull in that order (Porretta et al 1957, Schajowicz & Slullitel 1966 Barry 1969)

Vertebral Paget's disease with sarcomatous change is exceedingly rare (Porretta et al 1957, Price & Goldie 1969) Including our patient there are now seven reported cases of histologically proven Paget's sarcoma of the vertebral column causing neurological complications

The seven case reports are summarized in Table 1 Symptoms of backache or sciatica had been present for an average of 13 months (range, 2 weeks to 4 years) Neurological signs were present on average two and a half months (range, 1 week to 12 months) At least two patients (nos 5 and 7) showed no external evidence of Paget's disease Paraparesis of varying degree was present in all patients on admission to hospital A correct radiological diagnosis was made in the first three cases only Polyostotic Paget's disease was present as a rule and a block was seen on the myodil column whenever myelography was performed

Temporary (approximately 1 month) relief of pain and neurological signs was gained by all the five patients who had



Figure 1 Sclerosis of the bodies of L_1 and L_2 with possible destruction of right pedicle at L_1 A complete block to the flow of myodil at L_1 level

On the day after operation the patient noted relief of pain and some recovery of power in the right leg By the eleventh postoperative day she had regained bladder and bowel control and began exercising out of bed One month post operatively a right pleural effusion was noted This was aspirated but soon recurred and a week later one and a half litres of haemorrhagic fluid was withdrawn Subsequently lung metastases were noted in the left mid zone In spite of teletherapy her condition deteriorated rapidly and she died on the 13th of May 1974 Permission for post mortem examination was denied

DISCUSSION

It is now 100 years since Sir James Paget of St Bartholomew s Hospital, London, presented his original paper describing the condition he called osteitis deformans (Paget 1877) This disease is said to occur in 3 7 per cent of the population over 40 years of age (Collins 1956) The majority are subclinical cases, the pathology commonly involving the silent areas with lumbo-sacral spinal involvement in 76 per cent of cases (Dickson et al 1945, Collins 1956)

Vertebral Paget's disease causing neurological complications is rare—only 104 cases have been reported Wyllie (1923) was the first to describe this problem Turner (1940) reviewed 34 cases and suggested the pathogenesis of neurological signs to be due to

a) progressive bony expansion causing spinal compression,
b) *cord ischaemia without spinal* obstruction,
c) vertebral displacement

The typical patient is said to be a middle-aged male with a history of 12 months insidious progressive paraparesis, X-ray signs of Paget's disease in the thoracic spine and a block in the myodil



Figure 3 Paget's disease of bone with cement mosaic rimmed by malignant osteoblasts

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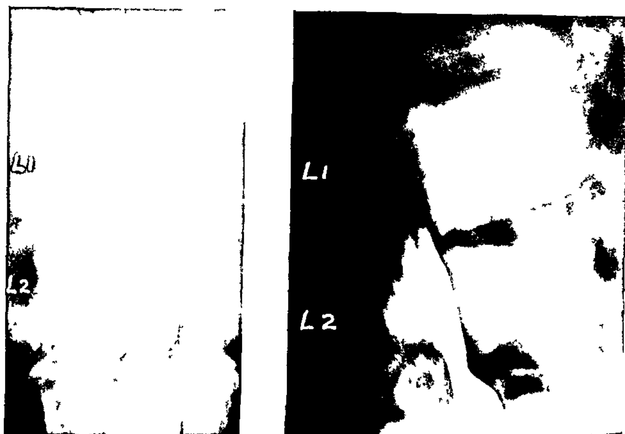


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Paget's sarcoma of the vertebral column

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ertebral Paget's My dil block T_{5-6}	Home 1 month Death 5 months post-op	Osteosarcoma
l lyostot c Paget's My d l bl ck l	Slight improvement Death 6 weeks post op	Osteosarcoma
l oly stotic Paget s) N t X rayed	Death shortly No operation	Osteosarcoma
l lyostot c Paget s M odit l l ck T_1 + l	Urine control 3 days Death 5 months post op	Osteosarcoma
l ly stotic Paget s M d l l l ck L	Visceral control 10 days Walking 2 weeks Death 7 weeks post-op + DXT	Osteosarcoma L

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Table 1 Summary of the seven case repor

Cases reported	History	Examination
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2 52 year old male (Campbell & Whitfield 1943)	4 months right sciatica 1 month frequent micturition	Cauda equina signs
3 53-year-old male (Campbell & Whitfield 1943)	1 month back pain 1 week leg weakness	Spastic paresis Distended bladder
4 64 year old female (Finneson et al 1958)	4 years low back pain 1 month bilateral sciatica + leg weakness	Flaccid paraplegia with incontinence
5 64 year old male (Barry 1969)	12 months difficulty walking	Spastic paraparesis T_5 level
6 53 year old male (Sadar et al 1972)	2 weeks bladder paresis	Flaccid paraparesis T_{11} level + sphincter loss
7 58-year-old female (Shannon & Hopkins 1977)	4 months low back pain 2 weeks paraparesis	Flaccid paraparesis + sphincter loss

operative decompression performed All patients died within 6 months of admission (average 4 2 months) Widespread metastases were seen in the four patients on whom post-mortem examinations were recorded

Conclusions

It is important to recognise benign lesions causing spinal cord and root compression Paget's disease of the vertebral column, often seen in orthopaedic clinics, sometimes causes backache, but seldom causes neurological complications Cord and root compression in Paget's disease of the spine is rarely due to malignant change The vast majority of patients with spinal compression who develop slowly progressive paraparesis (12 months) have simple Paget's disease (Turner 1940, Sadar et al 1972) For these patients operative decompression should be advised since this frequently provides prolonged relief (Miller 1967, Siegelman et al 1968, Direkse & Milnes 1970, Cartlidge et al 1972)

A rapidly developing paraparesis (2 to 3 months) in a patient with Paget's disease of the spine suggests sarcomatous change This possibility should be confirmed histologically

In view of the inevitably rapid fatal outcome in the patient with sarcoma, the value of an extensive spinal decompression must be questioned The histological diagnosis may well be established by a simpler procedure such as a needle or limited open biopsy, allowing palliative treatment of a non-surgical nature to be undertaken

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f Paget s sarcoma of the vertebral column

X ray	Progress	Histopathology
Paget s subluxation L_3 and multicentr c sarcoma	Death within 3 months No operation	Sarcoma L_1 L L_5
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Vertebral Paget s Myodil block $T_{5\ 6}$	Home 1 month Death 5 months post op	Osteosarcoma
Polyostotic Paget s Myodil block L_2	Slight improvement Death 6 weeks post op	Osteosarcoma
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PROCESSUS SUPRACONDYLOIDEA HUMERI WITH CONCOMITANT COMPRESSION OF THE MEDIAN NERVE AND THE ULNAR NERVE

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Compression of the median nerve and the ulnar nerve due to the anatomical anomaly processus supracondyloidea humeri is a rare condition A case of combined median and ulnar nerve compression is described Diagnostics and treatment are discussed in the light of the present case history and those described in the literature The conclusion is that the treatment should be subperiosteal resection of the process together with the origin of the pronator teres muscle

Key words supracondylar process anatomical variation nerve compression median nerve ulnar nerve operative treatment

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Processus supracondyloidea humeri (PSH) is a well known congenital and often hereditary anatomical variation which in the European population occurs with a frequency of approximately 1 per cent (Terry 1930)

Due to its anatomical location PSH may in rare cases result in compression of the median nerve the ulnar nerve and the brachial artery In the literature, 13 cases have been described of definite symptomatic compression of the median nerve due to PSH (Barnard & McCoy 1946 Gantert & Alzheimer 1956 Goulon et al 1963 Kessel & Rang 1966, Mandruzzato 1938 Moraes 1950 Mumenthaler 1961 Solieri 1929) there have been four cases of compression of the ulnar nerve (Fragiadakis & Lamb 1970 Goulon et al 1963 Mumenthaler 1961) as well as one case with combined compression of the median and the ulnar nerve (Mumenthaler 1961)

The purpose of this paper is to describe a case of combined compression of the median and the ulnar nerve

CASE REPORTS

A 20 year old female clerk was referred to the department in October 1974 after 6 months with symptoms of right sided compression of the ulnar nerve and to a lesser extent of the median nerve as well without any history of injury The symptoms consisted of paraesthesia and dysaesthesia in all five fingers Furthermore there were symptoms of hypersensitivity to cold increased sweating a feeling of rigidity and slightly reduced strength

The symptoms were aggravated by use of the hand and fingers particularly during pronation of the forearm but they also continued as resting phenomena after working for some length of time There was also pain along the inside of the upper arm and gradually the symptoms began to interfere with the patient s work

On examination she had light dysaesthesia of all fingers but no atrophy or paresis of the hand muscles Five centimeters proximal to the



Figure 1 The supracondylar process the position of the median nerve and the brachial artery and branches (From Kohler & Zimmer 1967)

medial epicondyle a pressure tender bony prominence could be felt and pressure in this area caused paraesthesia in all of the hand There was normal pulsation Roentgenograms of the right elbow and upper arm showed a 15 mm long processus supracondyloidea humeri At operation a distended median nerve and brachial artery were found passing beneath the process from behind and continuing profound to the part of the pronator teres muscle which originated from the process The ulnar nerve passed behind the brachial artery and behind the process but close to the latter The nerves were found to be slightly succulent and greyish The bony process was chiselled subperiosteally and removed along with the connecting part of the pronator teres muscle allowing the artery and nerves to pass without stretching There were no symptoms at all after 3 weeks but after 2 months the patient complained of recurrence of the symptoms of ulnar nerve compression in the right arm At objective examination the only symptom appeared to be percussion paraesthesia released from the upper edge of the cubital tunnel A simple decompression of the ulnar nerve was carried out and the nerve was found to be without changes The previous field of operation was explored but osseous recurrence or cicatricial changes as the reason for the ulnar compression were not found

There was an instant relief after this intervention However, 6 weeks later gradually increasing ulnar nerve compression symptoms recurred little by little with release of percussion paraesthesia from the area around the previous PSH Eight months after the second operation an anteposition of the right ulnar nerve was carried out and compressing cicatricial fibrosis was found around the ulnar nerve for a distance of approximately 4 cm just distal to the previous PSH

After the latter operation the symptoms disappeared gradually, and at a follow up examination 4 months later the patient had been back to full time work for 3 months From time to time there had been only very brief par



Figure 2 X ray of the right humerus in our patient showing the supracondyloid process

aesthesia like sensations in the fourth finger which had not interfered with her work Objective examination showed no difference between the two upper extremities and there was no sign of osseous recurrence

DISCUSSION

Symptomatic nerve compression caused by PSH is, according to the literature, exceedingly rare and consequently it might be overlooked even if the diagnosis is relatively easy

Compression of the median nerve is much more frequent than compression of the ulnar nerve, most likely because the ulnar nerve, as described by Goulon et al (1963), rarely takes a course which brings it in direct contact with PSH

The diagnosis is based on non traumatic median or ulnar nerve compression related to a palpable and roentgenologically apparent beak like prominence in an anteromedial position on the distal humerus It is characteristic that the symptoms are aggravated by lower arm pronation as described by Barnard & McCoy (1946) which was also the case in the patient presented here Among others Kessel & Rang (1966) have described compression of the brachial artery or, in cases of a high division of this artery, of the ulnar artery, giving ischaemic pain in the forearm and the hand— forearm claudication In the patient presented here there was peroperative indication of light compression of the brachial artery, but no symptoms of forearm claudication

According to most authors, the treatment of PSH consists of operation with subperiosteal resection of the process and the part of the pronator teres muscle which originates from it Subperiosteal chiselling is necessary in order to avoid recurrence of PSH, as in the case presented by Solieri (1929)

The reason why the present patient had to be operated upon three times was the fact that besides symptomatic PSH she developed both compression of the ulnar nerve in the cubital tunnel and postoperative perineural fibrosis

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THE MONK HIP ARTHROPLASTY

Preliminary Report on the Uncemented Standard Monk Prosthesis

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The Monk hip prosthesis is a one piece block prosthesis consisting of a metal femoral component with the head enclosed in a polyethylene cup The standard type is fixed without cement Most of the hip movements take place between the metal and the polyethylene cup 104 Monk arthroplasties were performed 95 hips in 84 patients have been available for regular examination and follow-up The follow up period was from 12 to 30 months, an average of 19 months Out of the 95 cases, 72 were classified as excellent, 10 as good and 13 as unchanged The results obtained during the first year were comparable to those obtained with the Ring prosthesis, but during the following 1½ years eight revisions had to be performed The main reason for the deterioration was loosening of the femoral component probably because in the standard type it is too short and the neck has too great a varus inclination resulting in a rather strong tilting force Because no cement has been used the revisions have been quite easy to perform Another reason for failure has been wear of the polyethylene cup, in one case with a massive foreign body reaction In spite of a short follow-up period this report illustrates the failures due to the design of the prosthesis, and therefore an improved construction is now in use

Key words bipolar system, block prosthesis, Monk arthroplasty, Ring arthroplasty, total hip replacement, uncemented hip prosthesis

Accepted 2 iii 77

The use of acrylic cement has created many problems and complications This fact has initiated many attempts to construct an uncemented total hip prosthesis One of the best known uncemented hip prostheses is the Ring prosthesis, introduced by Ring in 1964 (Ring 1974) We have used it for some years, and an assessment made together with several other Danish orthopaedic departments revealed results similar to those obtained with the various cemented types (Paaby 1974)

In February 1974 we started to use the prosthesis developed by Monk in Liverpool, for several reasons The Monk prosthesis has a metal-to-polyethylene articulation, it is constructed as a one-piece block prosthesis which is quite easy to handle, and the operative procedure causes less trauma than the Ring operation

The Monk prosthesis consists of a metal femoral component shaped somewhat like the well-known Moore prosthesis, but with a smaller head The head

is enclosed in a polyethylene cap When placed in the acetabulum most of the movement takes place between metal and polyethylene

After the first year the results were comparable to those obtained with the Ring arthroplasty (Hansen 1975), and compared to the Ring operation the need for blood transfusion was diminished to about half

The follow up has been continued with regular x-ray examinations and clinical evaluation This has revealed that the satisfying primary results are not long-lasting in many cases So we find it mandatory to publish this report in order to warn against the use of the short stemmed type of prosthesis although the observation period is still quite short We are aware that the Monk prosthesis is in wide-spread use, but we have not been able to find any other publication on this subject

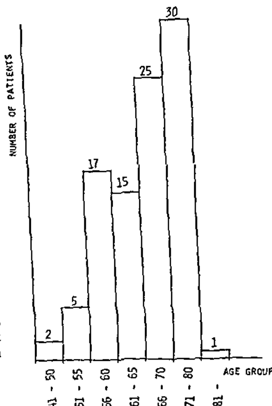


Figure 1 Age distribution of patients having 95 hip operations (52 women 43 men)

PATIENTS AND METHODS

In the period from February 1974 to September 1975 104 Monk arthroplasties were performed on 94 patients One patient moved to another county and could not be followed up Eight patients died in the follow up period Ninety five arthroplasties in 84 patients remained for final evaluation 45 were women

Out of 10 bilateral operations five were done in one stage Two other patients had a Ring total hip on the other side Symptoms had lasted on an average 6 7 years Seventy one of the operations were performed on patients over the age of 60 years and 31 operations on patients over 70 years The age distribution is shown in Figure 1

Six operations were performed for recent femoral neck fractures Fifty four had osteoarthrosis ten rheumatoid arthritis and two

... as been intolerable pain in the hip In 37 cases there have been other major illnesses with an influence on the walking ability

The operative procedure was the same as we have used for the Moore arthroplasty with some small modifications ("southern approach") (Jensen & Holstein 1975) In 37 cases the acetabular bed was prepared with a spherical reamer of the same size as the prosthetic cup In six cases a completely new acetabular bed was prepared with the reamer because of marked deformation of the region In fresh femoral neck fractures no reaming was done

In five instances adductor longus tenotomy was performed percutaneously No systemic antibiotics were used but in 64 operations the wound was irrigated with nebacetin containing saline solution No routine anticoagulants have been used

In all cases presented in this material the rather short stemmed standard Monk prosthesis was used The fixation has in all cases been mechanical No cement was used

On the second postoperative day the patients were allowed to sit in a chair and they started full weight bearing 10–12 days after surgery

The observation time has been from 1 year to 2¼ years on average 1 6 years

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Figure 3 Circular lines of wear on the polyethylene cup of a prosthesis removed after 1 year



Figure 4 Severe wear of a cup removed after 2 years

ments include the eight re operated cases *before* the revision

At the final follow up the patients were asked for their opinion Accordingly 72 cases (= 76 per cent) were classified as excellent 10 (= 10 5 per cent) as improved and 13 (= 13 5 per cent) as unchanged In no case was the condition considered to be deteriorated after the operation

The prostheses removed all had some kind of wear visible on the polyethylene cup some of them demonstrating that some movement must have taken place between the cup and the acetabulum Figures 3 and 4) So far we have not seen any migration of the prosthetic head into the pelvic bone but in one case with very severe wear on the polyethylene cup Figure 4) there was a massive foreign body reaction in the surrounding tissues

DISCUSSION

After only 1 year of experience with the standard Monk prosthesis we were optimistic about the results (Hansen 1975) However a longer observation period has revealed that 8 out of 95 hips required revision and furthermore the condition in a few other cases is deteriorating

The main reason is osteolysis with loosening of the femoral stem Considering the development of the Moore and Ring prostheses where longer stems are now available it seems obvious that the femoral stem of the standard Monk prosthesis is too short to secure a stable fixation Furthermore the neck of the Monk prosthesis has too great a varus inclination resulting in a strong tilting force which a short stem especially is unable to counteract As shown in Figure 5 the short Ring prosthesis has a better

RESULTS

Mortality Two patients died because of pulmonary embolism, one 16 days, and the other 17 days, after surgery Both were suffering from complicating illnesses preoperatively A third patient, an 87-year-old female with a femoral neck fracture and severe heart disease, died 2 months postoperatively. Five other patients died 6 to 26 months after the operation from diseases unrelated to the operation

Local complications at surgery Two minor fractures occurred, one in the trochanteric region and one in the neck of the femur Full weightbearing was delayed 4 and 6 weeks in these cases Otherwise the fractures had no influence on the postoperative course In one case a spiral fracture occurred in the femoral shaft during the attempt to disarticulate the femoral head This fracture was treated immediately with osteosynthesis, and weightbearing had to be delayed 8 weeks

There has been no dislocation postoperatively

Superficial wound infection occurred in three cases, which all healed, one after debridement and re-suture No deep infections were detected

Besides the two fatal pulmonary embolisms there have been five thrombo-embolic complications which all responded well to treatment with anticoagulants and there have been no sequels

Osteolysis seems to be the main problem We have seen 20 cases, three without symptoms In nine cases the osteolysis was associated with pain during walking The lower tip of the femoral stem invaded the lateral cortex of femur in three of these (Figure 2) In one the symptoms are so severe that revision may be the end-result In eight cases with no improvement a revision has already been *performed* in one with a Ring arthroplasty, in four with a cemented

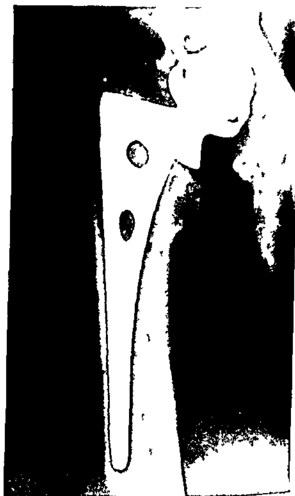


Figure 2 The standard Monk prosthesis in a case needing revision The prosthesis has tilted the tip of the femoral stem has invaded the lateral cortex and there has been considerable resorption of the calcar

Monk prosthesis and in three cases the prosthesis was removed At revision no positive cultures for bacteria were found yet one of the Girdlestone hips still has a fistula

The overall results have been classified according to the code given by Merle d'Aubigné & Postel (1954) In this code score points for *pain, movement* and *walking* are recorded "0" stands for a very poor condition and "6" for a normal condition

The score points for pain improved from 1 6 before the operation to 5 1 after, for movement from 3 5 to 5 2 and for walking from 2 6 to 4 0 These assess-



Figure 3 Circular lines of wear on the polyethylene cup of a prosthesis removed after 1 year

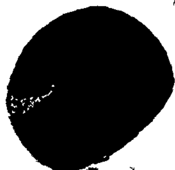


Figure 4 Severe wear of a cup removed after 2 years

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Figure 5 The short Ring prosthesis has the neck in a valgus position in contrast to the standard Monk prosthesis giving a direct transmission of the load and a weak tilting force on the femoral component



Figure 6 The Monk prosthesis with a Thompson stem for fixation with cement transmits the forces more directly than the standard type

design Also the Monk prosthesis with a Thompson stem for cementing has a better design than the standard type (Figure 6) As stressed by Brunelli (1977) this "medialization" diminishes muscular contracture and forcing of the stem onto the lateral cortex of the femur

The problem of wear of the polyethylene has previously been reported by several authors Especially the Oscobal prosthesis has shown severe wear after a very short time, probably because this construction necessitates a *great deal of* movement between the polyethylene cup and the acetabulum (Dahl & Mikkelsen 1976)

In the Christiansen replacement system with *trunnion bearing* it has been necessary to give the polyethylene a metal cover (Christiansen 1974) Recently the Monk prosthesis has been available with a similar metal cover This may possibly lead to an increased risk of migration into the acetabulum as has been seen with the Moore prosthesis in some cases Because of the rather small movements between the cup and the acetabulum this risk is not considered to be *very high*

Although many of the problems regarding the use of acrylic cement seem largely to have been solved, many *efforts*

are still being made all over the world to develop better uncemented types of hip prostheses In the United States the Gilberty prosthesis utilizes exactly the same bi polar principle as the Monk prosthesis The Sivash prosthesis can be fixed either with or without cement (Radulovic et al 1972) In Switzerland Mathys has developed an iso-elastic plastic material which works well in finger joint prostheses but is too weak for hip reconstruction as yet (Mathys 1973) The new total Judet prosthesis utilizes a very rough surface for fixation into the bone It still remains to be proved which principle is the best

The advantages of the Monk prosthesis are the comparatively atraumatic operative procedure (very similar to the insertion of the well known Moore prosthesis), the short recovery period after the operation and the quite good possibilities for revision should this be found necessary

However the results must be long lasting and comparable to other types of prostheses and according to our results we cannot recommend the standard Monk prosthesis

We have therefore changed to the new Monk prosthesis with a long straight femoral stem like the Ring and Moore prostheses and a metal covering on the polyethylene as used in the Christiansen prosthesis Time will tell if this construction solves the mechanical problems or if in addition the neck has to be made shorter and with a greater valgus inclination as in the design by Brunelli (1977)

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PARA-ARTICULAR OSSIFICATION FOLLOWING HIP REPLACEMENT

70 Arthroplasties ad modum *Moore using McFarland's Approach*

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Seventy patients representing all the survivors from a group of 117 consecutive Moore arthroplasties were examined 2 years after the operation A high incidence of para articular ossification was observed The ossification was associated with impaired function of the hip joint. The separation of periost and fascia from the greater trochanter in McFarland s approach may be responsible for the high incidence of bone formation This theory is compatible with experimental evidence

Key words myositis ossificans, femoral neck fracture, Moore prosthesis

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Arthroplastic operations on the hip may be followed by characteristic bone formation in the periarticular tissue One month after the operation these changes are seen on the X-ray film as a faint shadow which, in a few months, grows more intense and assumes a trabecular structure

Interest in this problem has been revived by the increasing use of hip replacement, but the cause of the bone formation is not understood The reported incidence of this complication varies widely, and there is disagreement regarding the significance of the para-articular bone in hip function

In Department 9 of the Copenhagen Municipal Hospital we have found ossification to be common after hip replacement Therefore, we have performed a follow-up examination of all the available patients subjected to this operation during a specified 2-year period, in order to elucidate the incidence and classify the calcification We also studied its influence upon the final result and tried to clarify the aetiology

PATIENTS AND METHODS

During the 2 year period from 1 4 1969 to 31 3 1971 a total of 117 hip replacement operations were performed according to Moore (1957)

One hundred and twelve operations were primary treatment of a recent medial fracture of the femoral neck Sixty seven *patients* had the operation within 24 hours of fracture whereas in 45 patients the operation was deferred because of associated diseases, for 2 35 days (mean 8 days) and temporary traction was used in the intervening period

Five operations were performed as a secondary measure after failure of osteosynthesis or conservative treatment of medial fractures of the femoral neck

At all the operations the approach was the McFarland Osborne (1954) anterolateral *incision* detaching the insertion of the gluteus medius muscle from the greater trochanter in continuity

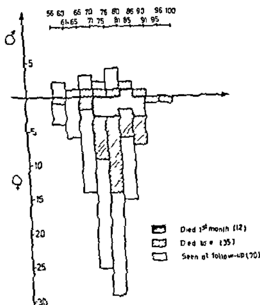


Figure 1 Age and sex distribution of 117 patients

with the origin of the vastus lateralis muscle The joint capsule was opened by an L-shaped incision and the femoral head was dislocated anteriorly during external rotation of the femur After insertion of the prosthesis and reduction the

started a day or two after the operation

Complications

Twelve patients died within the first month after the operation As shown in Figure 1 these patients were predominantly in the oldest age groups their mean age being 80 6 years

Seven patients developed sub fascial infection due to *Staphylococcus aureus* Two of them died within the first month and another two after 2 and 4 months respectively before the wound had healed In the remaining three patients with deep infect

cause of hip pain before the follow up examination

Follow-up

At follow up the patients were questioned regarding pain walking ability and working capacity The gait was observed, and the patients were subjected to a clinical examination of both hip joints measuring mobility A Trendelenburg sign if present, was recorded Radiographs of the operated hip both anteroposterior and lateral views were taken

RESULTS

In evaluating hip function we used the system of Merle d'Aubigné & Postel (1954)

Periarticular calcification was assessed as follows on the basis of the radiographs (Rosendahl et al 1972)

+ Faint shadows of minimal extent
++ Scattered lumps of calcification in the periarticular tissue or small exostoses from the trochanter or acetabulum, of a radiopacity approximately the same as that of normal bony tissue
+++ Widespread calcification with distinctly trabecular structure

Among 70 patients included in the follow-up, we found no calcification in 7, mild calcification (+) in 20, moderate (++) in 26 and severe (+++) in 17

Table 1 Degree of calcification as compared with the clinical result In the two groups with the poorest results all patients have calcification

Clinical results	Calcification –	+	++	+++	Total
Very good	4	3	7	2	16
Good	1	4	1	2	8
Medium	1	6	6	4	17
Fair		2	4	2	8
Poor	–	2	6	5	13
Total	6	17	24	15	62

Table 1 lists the calcification compared with the clinical result Five patients had to be excluded from this evaluation, as their walking was inhibited by other causes hemiparesis in two, disseminated sclerosis in one, and severe senility in two A further three

patients were excluded in whom the poor result was due to removal of the prosthesis because of pain A relationship between increasing calcifications and poor function is seen

The calcifications usually occurred in the gluteus medius muscle The relationship between insufficiency of this muscle, indicated by the presence of Trendelenburg's sign, and the degree of calcification is shown in Table 2 In this table increasing calcification seems to be associated with poorer function

Table 2 Degree of calcification as compared with the occurrence of Trendelenburg's sign Increasing calcification is seen to be associated with insufficiency of the abductor function

Trendelenburg's sign	Calcification —	+	++	+++	Total
Negative	6	8	15	4	33
Positive	0	9	9	11	29
Total	6	17	24	15	62

Table 3 Calcification in eight patients excluded because of functional impairment due to other causes

Reason for exclusion	Degree of calcification
1 Hemiplegia	—
2 Hemiplegia	+++
3 *Senile dementia*	++
4 *Senile dementia*	+++
5 Disseminated sclerosis	+
6 Implant removed	+
7 Implant removed	+
8 Implant removed	++

Table 3 shows the calcification in the eight patients excluded because of functional impairment due to other causes

Deep or superficial infection had no influence upon the occurrence of calcifications, and there was also no difference between the groups of patients having acute and elective surgery

DISCUSSION

Periarticular ossification after hip replacement is a kind of posttraumatic myositis ossificans This is a misnomer as it is not an inflammatory condition but the disease entity is well-known and has been well described, clinically and histologically It is known that the calcification arises through metaplasia of connective-tissue cells in the peri and endomysium The process progresses rapidly As early as 3 or 4 weeks after the trauma the calcific shadow may be discerned on the X-ray film, and biopsy at this time may be misinterpreted as osteosarcoma owing to the numerous mitoses The true cause of calcification following hip replacement has not been definitely established In the opinion of *Boitzy & Zimmermann* (1969) the growth is elicited by bony splints and bone marrow from the operation However, careful flushing with saline before seating the prosthesis cannot prevent the calcification Sarmiento & Grimes (1963) assumed that injury to the acetabular rim was the eliciting factor and tried to prevent calcification by sparing this area during the dissection However, the great majority of calcifications observed by us have clearly arisen from the trochanteric area Also the Moore operation, using modest dissection, and the McKee total replacement, with comprehensive dissection at the acetabulum, appear to be followed by the same rate of calcification

Blunt injury to muscle tissue is the main factor in classical posttraumatic myositis ossificans This factor presumably contributes to the development of calcification following hip replacement as all approaches to the hip joint involve some injury to muscles by the retractors

Periarticular calcification has occurred in practically all major series of hip replacement The incidence is usually stated to be about 10 per cent (Eftekhar 1971, Patterson & Brown 1972), but

many authors have reported divergent rates with a range as wide as from a few up to about 50 per cent The explanation is possibly that minor degrees of cal cification are apt to be overlooked on the X ray film

Nollen & Slooff (1973), using a clas sification almost identical to ours, found calcifications in 53 per cent, which is considerably below our 90 per cent We employed McFarland & Osborne s incision (1954) which differs from most other approaches to the hip joint in the extensive dissection of the periosteal muscle insertion on the greater trochanter

Zacchalini & Urist (1964) have demon strated that detachment of the periosteum is the most reliable method for inducing experimental calcifications, in particular if a distance of a few milli metres is established between the bone and the detached periosteum In this way *they could* induce severe calcification in 36 out of 36 rabbits On the other hand injury to the muscle and periosteum caused no calcification in any rabbit

In the McFarland approach to the hip joint the strong gluteus medius muscle is re inserted by non absorbable sutures through drill holes to the greater troch anter When *walking exercises* are started a short time after the operation diastasis is apt to occur between the muscle periosteal flap and the bone and it is from this space that the calcification arises Insufficiency of the *re insertion* of the gluteus medius may explain the relationship demonstrated by us between Trendelenburg s sign and bone formation In this connection however, it must be pointed out that the dissection in McFarland s approach is performed close to the nerve fibres from the superior gluteal nerve which innervate the tensor muscle of the fascia lata *Together with* the gluteus medius muscle, this is the most important abductor of the *hip joint*

There is disagreement about the functional significance of the periarticular calcification following hip replacement Examples of a poor result in the presence of severe calcification are often mentioned but it is well known that even a very severe calcification is not incompatible with a satisfactory functional result

From the present study there is indication that calcification around the hip joint following hip replacement is associated with impaired function The marked impairment of abductor function is of particular importance

In order to prevent postoperative calcification one should avoid extensive dissection of the periosteum from the bone and abstain from approaches which demand this Flushing off bony splints and gentle retraction of the muscles must also be assumed to be of importance

If periarticular ossification develops after a hip replacement operation, treat ment should be attempted according to the lines of Bohler (1936) for dealing with classical posttraumatic myositis os sificans

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PROPHYLACTIC ANTIBIOTICS AGAINST EARLY AND LATE DEEP INFECTIONS AFTER TOTAL HIP REPLACEMENTS

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A review with a longer observation period is performed of a previously published double blind investigation of the prophylactic value of cloxacillin against late infections after total hip replacements In addition a retrospective patient material is examined The total material consisted of 1065 total hips 15 4 per cent deep late infections were found in the group without prophylaxis and 2 0 per cent in the one with prophylaxis The frequency of haematogenous deep infection was estimated to be less than 1 per cent

Key words infection prophylactic antibiotics total hip arthroplasty

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Cumulative experience during recent years has shown that the prophylactic use of antibiotics can substantially reduce the frequency of early postoperative infections after total hip replacements (THR) (Ericson et al 1973 Fogelberg et al 1970 Pavel et al 1974) It is, however still debatable whether such prophylaxis has any effect on the frequency of so called late infections Many orthopaedic surgeons are inclined to doubt whether such precautions as performance of the operation in a sterile box or the peroperative and early postoperative use of antibiotics really can prevent infections appearing months or even years after the operation Recent investigations, however have produced evidence strongly suggesting such a preventive effect (Ericson et al 1973) But corroboration of such an effect requires extensive investigations of several series followed up for a long time, especially since some of the late infections may be haematogenous and not due to implantation of bacteria during the operation

This paper concerns a) a review of a double blind investigation earlier published by Ericson et al (1973), b) estimation of the frequency of deep infection in a 7-year material of THR performed with and without prophylactic antibiotics

Previous investigation

In 1973, Ericson et al reported a double blind investigation of the prophylactic value of cloxacillin used in association with major operations of the hip The results as regards the THR can be found in Table 1 The result of a retrospective study was also reported The investigation showed that cloxacillin had a very good preventive effect on early postoperative infections However, the follow-

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to another hospital for further examination or treatment The few patients residing outside the receiving area of the hospital were followed up especially for any infection

Definition of deep infection

Only patients with positive aerobic culture from fistulae or abscesses or with positive aerobic or anaerobic culture from tissue specimens adjacent to the prosthesis or the surface of the cement are included Furthermore the patients had pain on weight bearing or during rest, roentgen signs of infection according to Bergstrom et al (1974) (radiolucent zone scalloping and/or periosteal reaction) and an ESR above 35 mm/1 hour without antibiotic therapy

RESULTS

Review of the patients in the double blind investigation

As seen in Table 1, two deep, late infections supervened in the cloxacillin group and seven in the placebo group during the 4 years that had elapsed since the preliminary study The difference between the cloxacillin and the placebo groups is significant The high frequency of infections in the placebo group may be explained by an epidemic accumulation of infections in Lund during the first half of 1971 The cause of the epidemic is not known

Retrospective investigation

The distribution of the infected and non infected cases found in both the double-blind investigation and the retrospective investigation is given in Table 2 The frequency of infection was much lower in the group that had received prophylaxis The difference is highly significant The interval between the operation and the review was between 2 and 8½ years in the retrospective study No serious adverse effects from the cloxacillin were seen during the investigation

Analysis of the infections that occurred despite prophylaxis

The findings are shown in Table 3 Laboratory studies (ESR, CRP, serum electrophoresis, white blood cell count, differential count and radiographic changes around the prosthesis) proved of little value in tracing the origin of the infection and are therefore not considered here

Two of the 14 patients belonging to the prophylactic group in Table 2 were excluded from this analysis as it was not quite certain that they had received an adequate prophylaxis

In Table 3 it can be seen that patients nos 1–4 had early infections appearing already during the healing of the operation wound Patients nos 5–7 were never symptom free after the operation and had slight pains when walking all the time, but the diagnosis infection was not

Table 2 Distribution of infected and noninfected patients in the two groups with and without prophylaxis

	With prophylaxis		Without prophylaxis		Total
	Not inf	Inf	Not inf	Inf	
Prospective study	58	2	44	14	118
Retrospective study	623	12	267	45	947
Total	681	14	311	59	1065
		(2 0 %)		(15 4 %)	

$P < 0.001$ (chi square with Yates correction)

Table 1 Incidence of deep, early and late infections in the double blind investigation

	Total	Cloxacillin		Placebo		
		Not inf	Inf	Not inf	Inf	
1–2½ years postoperatively	118	60	0	51	7	($P < 0.05$)*
5–6½ years postoperatively	118	58	2	44	14	($P < 0.01$)*

* chi-square with Yates correction

up was not long enough to warrant any conclusion as to the effect on the frequency of late, deep infections

MATERIAL AND METHODS

Only deep infections, both early and late, were considered Superficial infections which healed without developing into deep infections were not included

The material consisted of all 1130 hips (476 in men and 654 in women) operated upon with THR between 1968 and 1974 in the Department of Orthopaedic Surgery, University Hospital Lund (510 hips) and the Department of Orthopaedic Surgery, Malmo General Hospital, University of Lund Malmo, Sweden (620 hips) The mean age at the time of operation was 64 6 ± 9 3 years (average ± 1 SD) The youngest patient was 19 years and the oldest 87 The patients were reviewed during the first 3 months of 1977 which means between 2 and 9 years after the operation Sixty-five patients were not included either because it was not possible to ascertain whether prophylaxis had been given or because the patients had not appeared at follow up or review Patients who had died within 6 months of the operation without having had any known infection were not included in the investigation All operations were performed in conventional modern operating rooms

The investigation was divided into

a) a review of the 118 THR in the previously mentioned double blind investigation of *Ericson et al* (1973) in which the patients had been examined after a postoperative interval of 1 to 2½ years In the present review the reexamination was performed 5 to 6½ years postoperatively In the investigation by Ericson et al both superficial and deep infections were considered In the present study, only the deep ones were included

b) a retrospective investigation of the 947 other THR, 635 had received prophylaxis and 312 had not 761 were operated according to Charnley, 183 according to Brunswik and three according to McKee-Farrar

Prophylaxis

The antibiotic used was cloxacillin (Ekvacillin®, Astra Pharmaceutical, Sweden) The patient was given 1 g intramuscularly 1 hour before the operation and thereafter three times at 6-hour intervals This was followed by two tablets each containing 0 5 g which were taken in the fasting state with a glass of water The oral dose was given every 6 hours until the fourteenth day inclusive after the operation In addition the patient received oral probenecid in a dose of two tablets, each 0 5 g, twice a day during the same period as the cloxacillin In the double-blind investigation the placebo was given in the same way as the active substance The patients receiving placebo instead of cloxacillin were also given probenecid in the same dose Patients who found it difficult to take the tablets by mouth were given intramuscular injections The few patients known to be hypersensitive to penicillin or who developed such hypersensitivity during treatment were given lincomycin or cephalosporin, in corresponding doses, instead of cloxacillin Since January 1974 the prophylaxis at the Orthopaedic Department in Lund has been shortened to 1 week after the operation

Review

All patients with any symptoms or roentgen changes at the obligatory final follow up 6 months to 1 year after the operation were reexamined at regular intervals until the cause of the symptoms could be explained or the symptoms had disappeared It was not difficult to trace the patients with infection because patients operated upon at either of the two departments belonged to the receiving areas of the departments Therefore according to the Swedish insurance regulations they could not seek advice at any other hospital before they had first been examined at their local hospital where they were registered and if necessary, referred

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Table 3 (continued)

Pat	Onset of symptoms	Time of diagnosis of infection	Bacteria	Sensitive to cloxacillin	Comments
9	4 months postop	After 4 months	Staph aureus	Yes	Aspiration 4 months postop and biopsy 6 months postop gave Staph aureus
10	6 months postop	After 7 months However antibiotics since second month postop because of elevated ESR	Anaerobic streptococci and Gram neg. rods	Not tested for susceptibility	Aspiration from abscess 6 months after op gave growth of anaerobic streptococci Material obtained on extraction of prosthesis 1 year later gave Gram negative rods ESR never normalized
11	1 year postop	After 3 years and 2 months	Staph albus	Yes	Culture of two biopsy specimens, both positive Patient had previously had a Moore prosthesis which was replaced by a total prosthesis
12	2 years and 4 months postop	After 3 years and 4 months	Propioni bact acnes and Staph albus	Yes	Culture gave growth of Propionibact acnes and Staph albus from biopsy specimen Staph albus alone at extraction of prosthesis

made until after 2 3 years thus called late The patients nos 8 10 probably belonged to the same group but here nothing abnormal had been entered in the patients record Patients 11 and 12 were quite symptom free during 1 1½ years postoperatively

The long interval between the operation and the diagnosis of the infection can in some cases be explained by the difficulty at that time in making a firm diagnosis In retrospect we can now say that in several of these cases the diagnosis could have been made much earlier

Staphylococcus albus Propionibacterium acnes anaerobic peptococci and anaerobic streptococci were formerly considered " apathogenic or contaminations but are now known to cause a considerable number of the infections around total arthroplasties (Kamme et al 1974)

In seven cases the infection was caused by microbes sensitive to cloxacillin in spite of the fact that this antibiotic was given prophylactically

DISCUSSION

It has been clearly shown that antibiotic prophylaxis can substantially reduce the frequency of early infection after THR (Ericson et al 1973, Fogelberg et al 1970, Pavel et al 1974) Yet it is still debatable whether such prophylaxis can prevent so-called late infections That prophylaxis with cloxacillin has a good preventive effect against late infections around THR caused by the bacteriological flora existing at the two above-mentioned hospitals is however clear from the results of this investigation

The very high frequencies of post-

Table 3 Analysis of infected patients who had received prophylaxis

Pat	Onset of symptoms	Time of diagnosis of infection	Bacteria	Sensitive to cloxacillin	Comments
1	Immediately postop	Immediate deep infection after op	Proteus and enterococci	No	Immediate postop inf Culture of biopsy specimen
2	Immediately postop	Immediate deep infection after op	Proteus and Staph albus	No	Immediate postop inf Both proteus and Staph albus in each of six specimens taken from the tissue adjacent to prosthesis during extraction
3	Immediately postop	Immediate deep infection after op	E coli	No	Immediate postop inf Prosthesis extracted Repeated cultures from abscess gave abundant E coli
4	Immediately postop	Immediate postop infection	Anaerobic peptococci and anaerobic streptococci	Yes	The inf was in the beginning successfully treated with antibiotic, but prosthesis extracted after 2½ years Culture of biopsy specimen at extraction
5	Never quite symptom free	After 2 years 4 months	Propioni-bact acnes	Yes	Culture of six biopsy specimens positive at extraction of prosthesis Bilat op, other side not infected Reported clear difference between sides, became immediately symptom free in the uninfected hip
6	Never quite symptom free	After 2 years 7 months	Propioni-bact acnes	Yes	Culture of biopsy specimen from joint capsule positive Bilat op Other side not inf Reported clear difference between sides became immediately symptom free in the uninfected hip
7	Never quite symptom-free	After 3 years 4 months	Staph aureus	Yes	Culture of biopsy specimen positive at extraction of prosthesis Bilat op Reported clear difference between sides, became immediately symptom free in the uninfected hip ESR never normalized
8	3 months postop	After 6 months	Pseudomonas pyocyanea	No	July 1972 postop inf with pseudomonas pyocyanea after nailing of fracture of femoral neck Jan 1973 total arthroplasty 6 months postop fistula with pseudomonas pyocyanea ESR never normalized

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PERTHES' DISEASE

A Study of Radiological Features

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A study is presented of the radiographs of 68 patients with unilateral Perthes disease Two types of Perthes disease are identified frag menting and non fragmenting The two radiological types of the disease showed no significant differences in the age at diagnosis, the duration of symptoms before diagnosis and the duration of the disease However the radiologically measurable results at healing in terms of the epiphyseal acetabular acetabulum head and comprehensive quo tients were all very significantly worse when fragmentation had devel oped

Key words femoral head fragmentation Perthes disease

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The radiological features of Perthes dis ease have been studied extensively since its first description in 1910 (Legg Calve, Perthes) Waldenstrom (1922) described the typical radiological changes of the condition which included a stage during which the femoral head appeared to frag ment Ratliff (1956) and Somerville (1971) noted that fragmentation of the femoral capital epiphysis did not always occur in Perthes disease and that in such patients the shape of the femoral head at the time of healing was perfect

On the basis of antero-posterior and lateral radiographs taken at onset, Wal denstrom (1938) Fèvre (1955) and O Garra (1959) classified the disease according to whether the whole, or only part of the femoral head appeared to be involved they related the extent of in volvement to the prognosis Catterall (1971) described four different forms of Perthes' disease according to the amount of the femoral capital epiphysis affected by the disease as seen on the radiographs obtained at the time of diagnosis Kamhi & McEwen (1975) stated that Catterall s classification could not be applied until the disease had progressed to the stage of fragmentation Katz (1973) divided patients with Perthes' disease into three different groups, depending on the amount of the femoral epiphysis that appeared to fragment accordingly his classification can be applied only at a late stage of the disease

This paper reports a study of the radiographs of 68 patients with uni- lateral Perthes' disease, from diagnosis to healing Some 46 patients showed radiological evidence of fragmentation of the femoral capital epiphysis

operative infection reported from different parts of the world during the first years when total hip replacements were performed has now been considerably lowered through rigorous asepsis, e g, clean-air operating room enclosures or through the prophylactic use of antibiotics In this investigation the frequency has been lowered from 15 4 to 2 0 per cent with the use of antibiotics alone This reduction must depend on a decrease in the number of infections caused by implantation of bacteria during the operation Otherwise it is difficult to explain why this measure taken at the operation and during the following 1–2 weeks should have an effect for several years

If this argument is correct, haematogenous infections are to be found among those infections which occur despite the use of prophylactic antibiotics (Table 3) Patients nos 1–4 had early infections and were thus most probably infected during the operation Patients nos 5 7 were never pain-free which otherwise is the rule after a successful THR In patients 7, 8 and 12 preoperatively low ESR was never restored after the operation which indicates that all these five patients (5, 6, 7, 8, 12) were infected during the operation (Reichelt & Brand 1975) An argument against this is that patients 5–7 were infected with microbes sensitive to cloxacillin

In the remaining two patients (10, 11) there is nothing to specially indicate per operative infection The long symptom free interval in patient 11 rather indicates that the infection was haematogenous In the patient group without prophylaxis three patients (0 8 per cent) seemed to have haematogenous infections, two in association with sepsis caused by pneumococci The third patient had bilateral THR and suffered sudden pains in both hips after 3 years without symptoms and Staphylococcus aureus was found in both hips

This means that the frequency of haematogenous infections in this material was well under 1 per cent which is in agreement with the figures given by Charnley (1972), 0 30 per cent, and Artz et al (1975), 0 25 per cent

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Table 1 Forty six patients with the fragmenting type of unilateral Perthes disease

Initials	Age at diagnosis (years)	Length of history (weeks)	Length of disease (years)	Radiological assessment			
				FQ	*AQ*	*AHQ*	*CQ*
L H +	3	NK	3	45.6	103.6	91.1	80.1
M H +	4	20	3	58.1	93.8	65.1	72.3
K J +	5	6	2	77.3	87.4	84.3	83.0
B T +	5	NK	4	63.8	102.0	100.9	88.9
A D +	6	52	4	55.1	86.2	87.9	76.4
J K +	6	3	4	64.7	83.8	91.4	79.9
B I +	6	4	2	81.2	105.8	104.4	87.3
W C +	8	10	3	65.1	98.5	100.8	88.3
P G	3	NK	5	69.9	112.8	100.0	94.2
K O	3	1	2	83.7	79.9	95.5	87.7
R P	3	4	4	71.4	96.6	85.4	84.5
J I	3	1	3	58.3	82.9	123.2	88.1
D W	3	1	2	87.2	87.6	86.8	87.2
I B	4	26	2	79.4	80.4	93.2	86.0
R J	4	8	3	91.6	85.2	98.0	91.6
G S	4	6	5	91.2	100.0	86.5	92.6
R T	4	32	3	51.9	80.2	80.5	70.8
D W	4	12	3	69.3	45.8	92.8	69.3
S I	5	NK	1	66.3	63.2	100.9	76.8
M I	5	NK	2	89.7	89.3	107.8	95.6
L W	5	13	2	61.3	102.3	102.8	88.8
P M	5	1	3	66.1	86.9	85.7	79.6
D P	5	23	2	78.4	63.6	86.2	76.1
P R	5	4	3	40.8	60.6	71.1	57.5
S W	5	NK	2	59.9	94.1	84.2	79.4
S W	5	6	3	79.7	113.8	98.2	97.2
P B	6	2	2	49.4	100.7	91.9	80.7
K D	6	8	3	69.2	88.3	90.6	82.7
L H	6	3	3	67.6	83.1	95.0	81.9
A S	6	NK	1	65.1	90.5	94.7	83.5
M S	6	4	4	72.7	80.8	64.6	72.7
R T	6	NK	4	63.1	93.6	109.2	88.6
I W	6	0	2	72.8	114.0	94.0	93.6
P W	6	8	4	76.2	71.9	91.3	79.8
P B	7	4	3	48.7	63.9	67.6	60.1
A H	7	3	4	72.3	90.0	79.1	80.5
K H	7	5	2	64.4	72.0	93.2	76.5
B I	7	52	2	83.0	90.1	75.9	83.0
D W	7	NK	2	66.0	94.6	95.1	85.2
K H	8	NK	2	87.0	76.0	93.4	85.5
A T	8	8	3	65.9	96.8	95.0	85.9
R B	9	NK	2	72.3	65.0	79.6	72.3
D B	9	2	2	71.1	82.4	84.5	79.3
A S	9	3	3	54.9	83.7	93.3	77.3
R B	10	NK	1	60.6	67.3	89.7	72.5
R W	10	6	4	39.1	112.2	99.1	83.1
Mean	5.7	10.0	2.9	67.4	87.0	91.0	81.8

\+ girls
NK not known
0 less than one week

See text for radiological assessment abbreviations

PATIENTS AND METHODS

Patients The children in this study had been treated as in patients at three orthopaedic hospitals (The Marguerite Hepton Orthopaedic Hospital, Thorp Arch Wetherby, The Woodlands Orthopaedic Hospital, Bradford, The Children's Hospital, Nottingham) during the years 1944 to 1970 The methods used for treatment included traction, Thomas' splint, rest on Jones' abduction frame, hip-spica, broomstick plasters and patten ended calipers None of the patients had been treated by surgery Selection of the radiographs depended on the availability of antero-posterior and lateral views Patients with bilateral disease were excluded because of the difficulty of assessing the radiological findings when no unaffected contralateral femur was available to act as a control Of the 68 patients, 55 were boys and 13 girls

Radiological assessments The serial radiographs for each patient were examined and judged as to whether or not fragmentation had occurred in the femoral capital epiphysis during the natural history of the disease The epiphysis was considered to have fragmented if a part, or the whole, of the bony nucleus showed the development of one or more separate fragments within, or at the periphery of, the nucleus Healing was considered to have occurred when the radiological density throughout the femoral capital epiphysis, femoral neck and pelvis had returned to that observed in the opposite hip

At healing each hip was assessed quantitatively using the techniques of Heyman & Herndon (1950) The following quotients were measured the epiphyseal (EQ) the acetabular (AQ) and the acetabulum head (AHQ), the mean of these quotients was called the comprehensive quotient' (CQ)

Statistical analysis After categorizing the patients according to whether or not fragmentation had occurred t-tests were performed for each of these quotients, EQ, AQ AHQ and CQ Similar tests were carried out for the two radiological types of the disease with respect to the age at diagnosis and the duration of the disease from diagnosis to healing Further statistical analyses were undertaken to find whether the outcome of the disease was influenced by the sex of the patient, or the age at diagnosis (2–4 years and over 6 years)

RESULTS

In 46 patients (38 boys and 8 girls) the femoral capital epiphysis had undergone fragmentation In 22 patients (17 boys and 5 girls), the femoral capital epiphysis showed areas of increased and decreased density, irregularity of the outline of the bone nucleus, but no separate fragments Examples of each radiological type during the active phase of the disease are shown in Figures 1 and 2

The age at diagnosis, the duration of symptoms, the duration of the disease from diagnosis to healing and the results of the radiological assessments are summarized for the two types of the disease in Tables 1 and 2

The radiographs of the 46 children with fragmentation often showed changes in the metaphysis and occasionally in the acetabulum (Figure 3) The AQ (Table 1, mean 87 0) and the AHQ (Table 1 mean 91 0) suggested that lasting damage to acetabulum had occurred Moreover, the femoral head was markedly affected after fragmentation (Table 1 mean EQ 67 4)

The radiographs of the 22 children with the non-fragmenting type of disease showed, despite the whole head involvement, that the end results were satisfactory Metaphyseal changes, with an increase in the 'teardrop-distance' (Fyring et al 1965), were frequently seen in the radiographs of these children (Figure 4) In this type of the disease only the capital femoral epiphysis showed lasting effects after the disease had healed (Table 2, mean EQ 84 9) The acetabulum showed little sign of damage (Table 2, mean AQ 98 7) and the femoral head remained well covered by the acetabulum (Table 2, mean AHQ 97 7) The outcome of Perthes' disease of the non-fragmenting type was very satisfactory at healing (Table 2, mean CQ 93 8)

Differences between the findings for fragmenting and non-fragmenting hips are highly significant (Table 3)

The radiographs obtained at an early stage did not distinguish between the two radiological types (Figures 1 and 2)



Figure 1 e f 11 months after diagnosis Fragmentation continues head within the head apparent



Figure 1 g 37 months after diagnosis Healed Perthes disease FQ 33.7 AQ 63.9 AHQ 67.6 CQ 60.1

Only later (from 4 to 18 months) did it become apparent which of the disease types was present Once fragmentation is evident Catterall's (1971) or Katz's (1973) classification can be used to assess the prognosis

Tables 4 and 5 show there is no statistically significant difference between the two types of the disease with respect to the age at diagnosis the duration of symptoms before diagnosis and the duration of the disease Table 5 shows that the sex of the patient did not appear to influence the results as judged radiologically Also the duration of the disease in boys was similar to that in girls for both types of the disease Table 6 shows that when we compare the radiological quotients in early onset patients (2–4 years) with those for late-onset patients (6 years and above) the former enjoy on the average a slightly better result than late onset patients although only in two comparisons does the difference achieve conventional levels of significance

Figure 1 a b P.B. 7 year old boy. Duration of symptoms 4 weeks. Radiographs taken when the diagnosis was made.

Figure 1 c d Radiographs taken 7 months after diagnosis. Fragmentation becoming evident. Metaphyseal changes are present. Catterall Group III.

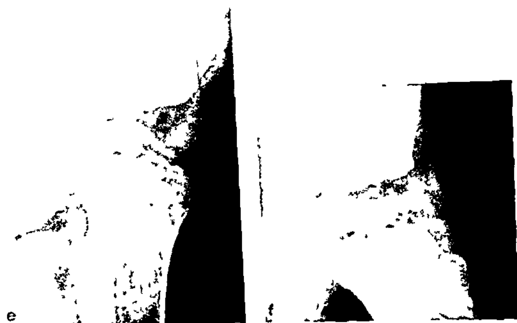


Figure 1 e f 11 months after diagnosis Fragmentation continues head within the head apparent

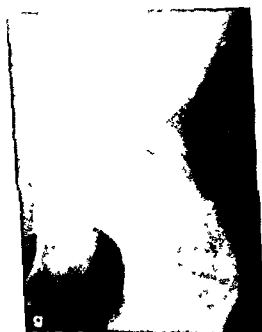


Figure 1 g 37 months after diagnosis Healed Perthes disease FQ 58.7 AQ 63.9 AHQ 67.6 CQ 70.1

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Table 2 Twenty two patients with the non fragmenting type of unilateral Perthes disease

Initials	Age at diagnosis (years)	Length of history (weeks)	Length of disease (years)	Radiological assessment EQ	AQ	AHQ	CQ
J A +	3	NK	3	68 4	118 4	103 1	96 6
L S +	5	NK	2	91 2	100 0	102 0	97 9
T D +	6	5	2	75 1	95 9	94 2	83 4
M P +	6	NK	3	84 7	105 0	88 7	92 8
S G +	6	1	2	83 3	100 4	95 9	93 2
G S	2	1	5	100 0	101 8	98 2	100 0
J B	3	3	1	88 8	87 6	90 0	88 8
S C	3	NK	2	72 6	90 1	88 4	83 7
C M	3	NK	2	100 0	98 4	106 3	101 5
P W	3	6	4	84 4	86 9	112 6	94 6
S B	4	1	1	91 0	100 0	93 3	94 8
S F	4	12	3	82 7	102 6	110 3	98 5
J P	4	1	4	102 6	100 0	88 7	97 1
L W	4	1	2	100 0	115 3	91 9	102 4
T D	5	2	2	80 4	100 0	109 1	96 5
J P	5	NK	2	76 2	104 0	103 4	94 5
M W	5	0	2	93 6	85 9	106 9	95 5
A B	6	6	3	78 3	96 6	91 4	88 7
D H	6	37	2	94 0	96 9	91 1	94 0
P B	7	8	1	70 7	98 4	100 0	89 7
M H	8	8	3	67 6	92 7	92 9	84 4
K T	10	6	3	81 7	95 4	89 8	88 9
Mean	4 9	6 1	2 45	84 9	98 7	97 7	93 8

+ = girls
NK = not known
0 = less than one week

See text for radiological assessment abbreviations

Table 3 Radiological quotients EQ AQ AHQ and CQ in fragmenting and non fragmenting types of unilateral Perthes disease

Radiological quotients	Groups tested (null hypothesis) Non fragmenting versus fragmenting (n = 22) Mean	Standard deviation	(n = 46) Mean	Standard deviation	P
EQ	84 9	10 7	67 4	13 0	* 8×10^{7}
AQ	98 7	8 0	87 0	15 3	* 9×10^{5}
AHQ	97 7	7 9	91 0	11 4	† 7×10^{3}
CQ	93 8	5 1	81 8	8 4	* 8×10^{10}

* t test 2 tailed equal variance
† t test 2 tailed unequal variance

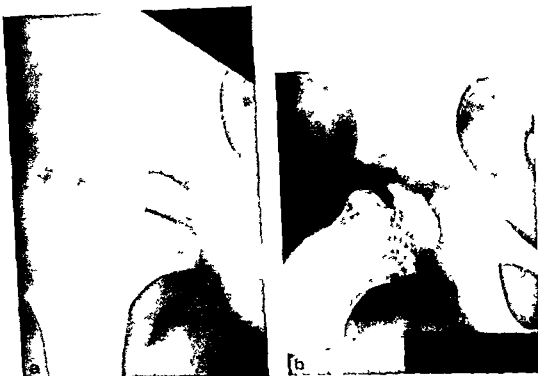


Figure 2 a b P.W. 3 year old boy. Duration of symptoms 6 weeks. Radiographs taken when the diagnosis was made. Changes in the metaphysis evident.

Table [illegible] Results of miscellaneous statistical tests

Parameter compared	Non fragmenting			Fragmenting			P	
	Mean	S.D.	n	Mean	S.D.	n		
Age at diagnosis	4.91 years	1.90 years	22	5.74 years	1.89 years	46	0.03[illegible]	
Duration of history	6.12 weeks	8.90 weeks	22	10.03 weeks	13.0 weeks	46	0.28	
Duration of disease	2.45 years	1.01 years	22	2.87 years	1.17 years	46	0.16	*
Duration of disease boys	2.47 years	0.55 years	17				} 0.89	*
Duration of disease girls	[illegible].40 years	1.12 years	5					
Duration of disease boys				2.8[illegible] years	1.23 years	38	} 0.50	
Duration of disease girls				3.12 years	0.83 years	8		
Duration of disease age at diag 2–4 years	2.[illegible]0 years	1.34 years	10				} 0.5[illegible]	*
Duration of disease age at diag [illegible] years and above	2.38 years	0.74 years	8					
Duration of disease age at diag 2–4 years				3.50 years	1.51 years		} 0.14	†
Duration of disease age at diag 6 years and above				2.75 years	0.99 years			

* t test 2 tailed equal variance
† t test 2 tailed unequal variance

c d

Figure 2 c d Radiographs taken 7 months after diagnosis Irregularities in the density and outl of the capital epiphysis but no separate fragment can be identified



Figure 2 e f Radiographs taken 14 months after diagnosis The radiological density of the cap epiphysis is still irregular but there is no fragmentation

Figure 2 g 48 months after diagnosis Healed Perthes disease FQ 84 4 AQ 86 9 AHQ 112 6 CQ 94 6

Figure 3 P R 5 year old boy at the time of diagnosis of Perthes disease This radiograph was taken 18 months after diagnosis and shows changes in the acetabulum in addition to the fragmentation of the capital epiphysis

Table 5 Radiological quotients in girls compared with those in boys for fragmenting and non fragmenting types of Perthes disease

Radiological quotients	Girls			Boys			P*
	Mean	S D	n	Mean	S D	n	
Non fragmenting							
FQ	80 5	8 9	5	86 2	11 1	17	0 32
AQ	103 9	8 7	5	97 2	7.3	17	0 097
AHQ	96 9	6 1	5	97 9	8 5	17	0 81
CQ	93 8	3 7	5	93 7	5 6	17	0 99
Fragmenting							
FQ	60 1	9 8	8	69 0	13 2	38	0 080
AQ	95 1	8 6	8	85.3	15 9	38	0 099
AHQ	90 7	12 5	8	91 0	11.3	38	0 95
CQ	82 0	5 9	8	81 8	8 9	38	0 95

* t test 2 tailed equal variance

Table 6 Radiological quotients in patients with the onset at 2 to 4 years compared with those in patients with the onset at 6 years and above

Radiological quotients	Type	Groups tested (null hypothesis) Early onset Mean	S D	n	Late onset Mean	S D	n	P
I Q	Non frag	89.0	12.0	10	79.4	8.4	8	* 0.074
	Frag	71.8	15.9	12	64.9	11.1	24	* 0.014
AQ	Non-frag	100.1	10.6	10	97.7	3.7	8	† 0.51
	Frag	87.4	16.8	12	87.1	13.7	24	* 0.96
AHQ	Non frag	98.3	9.2	10	93.0	3.7	8	† 0.12
	Frag	91.9	13.8	12	90.0	10.5	24	* 0.64
CQ	Non frag	95.8	5.8	10	90.0	3.2	8	* 0.022
	Frag	83.7	8.6	12	80.7	6.9	24	* 0.26

* t test 2 tailed, equal variance
† t test 2 tailed unequal variance



Figure 4 T D, 5 year-old boy Duration of symptoms 2 weeks Radiographs taken at the time of diagnosis The tear drop distance is increased on the right and the outline of the right capital epiphysis is irregular The femoral neck is broadened and metaphyseal changes are evident The child developed Perthes disease of the non fragmenting type

DISCUSSION

Our radiological study delineates two different types of Perthes disease The fact that we found no significant differences between the types in the age at diagnosis, the duration of symptoms and the duration of the disease, suggests that we are observing the same basic disease in its less and more severe forms We suggest, therefore, that the term 'dysplasia epiphysealis capitis femoris (Pedersen 1960, Meyer 1964, Lauritzen 1975) should not be applied to the non-fragmenting type of the disease, we found no evidence to support Meyer's (1964) suggestion that this type of the disease develops in a previously malformed or dysplastic epiphysis

The difference in the radiological course and the measurable results between the two types of the diseases is very marked We find that, in the non fragmenting type of disease only the capital epiphysis appears to be lastingly damaged although the whole of the epiphysis is clearly involved In the fragmenting type, the acetabulum and also the relation of the femoral head to the acetabulum appear to have been disturbed, in addition to the deformity of the femoral capital epiphysis The acetabular changes as described by the two quotients are perhaps secondary to the pathological process in the femoral head it seems clear, however, that they occur only when the femoral capital epiphysis fragments

Within the same type of Perthes' disease, the sex and the age of the patient at diagnosis appear to have little or no effect on the final outcome of the disease, although larger series are needed for definite conclusions

As this study did not include the radio

graphs of every child treated for Perthes disease in the three hospitals during the indicated period we can draw no firm conclusions about the relative frequency of occurrence of the two types We can state however that if the diagnosis is made at an early stage it is not possible to judge from the radiographs which type of the disease will develop Some 4 to 18 months later it will become clear which type of Perthes disease is affecting the child If fragmentation fails to appear on the radiographs a relatively good prognosis can be given if fragmentation manifests Catterall s (1971) or Katz s (1973) classification helps to forecast the final results of the disease

ACKNOWLEDGEMENTS

We wish to thank Emeritus Professor J M P Clark who helped to initiate this study and the orthopaedic surgeons of the Leeds/Bradford and Nottingham regions who gave us permission to study the radiographs of their patients

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ULTIMATE BONY FUSION OF LOWER LIMB JOINTS FOLLOWING SEVERE TRAUMA

JOHN PATRICK O'BRIEN

The Duchess of Kent Children's Orthopaedic Hospital and Convalescent Home, Sandy Bay, Hong Kong, and Department of Orthopaedic Surgery, University of Hong Kong Hong Kong

Three patients presented with limb deformity some years after being run over and sustaining degloving injuries of their lower limbs Spontaneous joint fusions were observed in each patient The causes of these could be i) Extensive intra articular fracture, ii) Prolonged immobilisation due to the scar tethering the joint, or most likely iii) A chronic low grade infection following compound joint injury with degloving

Key words articular joints, epiphyseal injury, spontaneous fusion trauma

Accepted 29 iii 77

It is well established that severe crush injuries to an epiphyseal plate will cause it to fuse prematurely and if significant growth potential remains, it will produce a shortened limb This is the so-called type (v) injury of the epiphyseal plate described by Salter & Harris (1963) Spontaneous fusion of lower limb joints following injury is much less common The purpose of this paper is to report three cases of this type and to comment on their possible aetiology

CASE REPORTS

Case 1 A 24 year old male complained of a stiff knee and shortening of the right lower limb When 8 years old his limb had been run over by a car resulting in an extensive degloving injury of the entire limb and a fracture of the mid shaft of the femur The details of the initial treatment were not available but it was essentially replacement of the degloved skin and conservative management of the fractured femur

On examination 16 years later, there were signs of extensive healed scars over the entire limb There was bony ankylosis of the knee with 4 cm of limb shortening Both the ankle and knee joints were fixed in 30° of flexion

Radiographs confirmed bony fusion of all three compartments of the knee joint in addition to the ankle and subtalar joints (Figures 1 2 and 3)

Case 2 A 16 year old male had his right foot run over by a car when he was a child aged 8 years There was no history of a fracture but there had been extensive degloving of the medial aspect of the ankle and foot Radiographs 8 years later demonstrated fusion of the ankle joint with the lower tibial growth plate intact (Figure 4)

Case 3 A 16 year old female presented with a valgus foot deformity When aged 7 years her right lower limb had been run over by a bus resulting in a degloving injury

Radiographs revealed premature fusion of the growth plates at both ends of the fibula with separation of the superior tibio fibular joint There had been spontaneous fusion of the entire

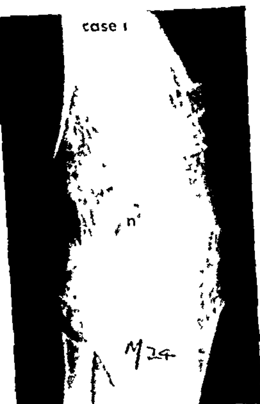


Figure 1 Case 1 Antero posterior radiograph of right knee in 24 year old male Severe degloving injury of limb when aged 8 years Note that bony fusion of the knee joint has occurred in ter condylar notch still visible (n)



Figure 2 Case 1 Lateral radiograph of the same knee showing spontaneous bony fusion of the patello femoral (arrow) and the tibio femoral joints

ankle joint with a valgus ankle yet the lower tibial epiphyseal plate was still visible (Figure 5

DISCUSSION

All three patients had been run over and sustained severe degloving injuries to their limbs Although the history of the initial injury was not complete in every instance only in case 1 was a definite history of an associated fracture at the time of injury elicited

A factor common to all patients was the extent of the soft tissue injury particularly around the joints which finally became fused

Several possibilities exist to explain this phenomenon of spontaneous joint fusion If the trauma had produced extensively comminuted intra articular fractures then bone of the adjacent epiphyses would have been brought into contact and this would inevitably have resulted in joint fusion It is likely that if this were the case, then injury of such magnitude should have damaged in addition the adjacent epiphyseal plates but this did not occur

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periods of time, it was totally replaced with intra articular fibrosis and eventually bone ankylosis

The scar tissue replacing skin and fatty tissue around the affected joints in this present series could have acted as a tether and a form of external bracing to the contained joints providing a degree of external prolonged immobilisation

An additional factor could have been the reduced blood supply to the joint with consequent poor cartilage nutrition and its subsequent atrophy All the affected joints reported here were largely covered by unstable thin skin graft or by tough, thick scar tissue, the result of healing by granulation and then fibrosis

A likely precursor to joint fusion is the presence of chronic low grade infection destroying articular cartilage All these injuries were the degloving type after being run over, and it must be assumed that there was a high incidence of compound injuries making joint infection a likely sequela With this destruction of cartilage the naked bony epiphyses are placed in contact and inevitably bony fusion will occur

This type of traffic injury to the lower limbs is common in children in Hong Kong where roads are narrow and both cars and children numerous These late findings are less common in European communities where, with extremely severe lower limb trauma, amputation is more likely to be carried out as a primary method of treatment In Hong Kong this is rarely the accepted treatment

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Figure 3 Case 1 Lateral radiograph of foot and ankle of same patient Note that fusion of the ankle and the subtalar joints have occurred with the foot in an equinus position No radiological signs of premature epiphyseal plate fusion

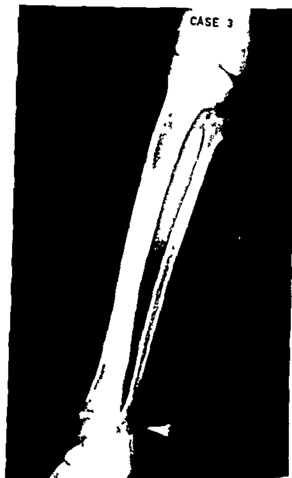


Figure 5 Case 3 Antero posterior radiograph of leg of a 16-year old female who had a severe degloving injury of the limb when aged 7 years Fusion of the upper and lower fibular epiphyseal plates has occurred also fusion of the ankle joint with the ankle in a valgus position



Figure 4 Case 2
Antero posterior radiograph of both ankle joints showing bony fusion of the right ankle joint Site of previous right ankle is level with lower fibular epiphyseal plate

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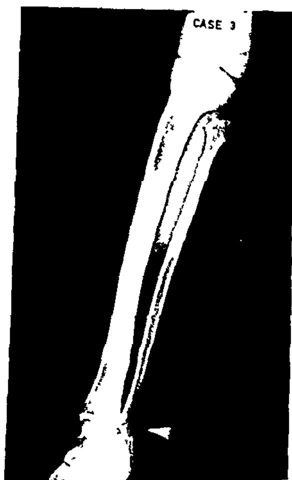


Figure 5 Case 3 Antero-posterior radiograph of leg of a 16-year-old female who had a severe degloving injury of the limb when aged 7 years Fusion of the upper and lower fibular epiphyseal plates has occurred, also fusion of the ankle joint with the ankle in a valgus position

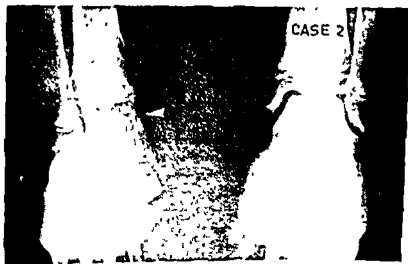


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Antero posterior radiograph of both ankle joints showing bony fusion of the right ankle joint Site of previous right ankle is level with lower fibular epiphyseal plate*

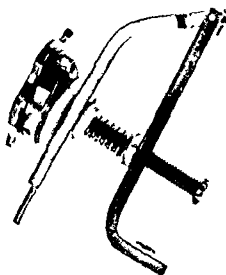
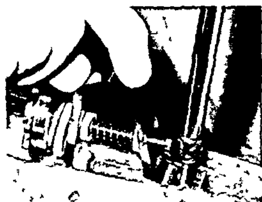


Figure 1 General view of the compression device designed for the technique described

from the medial aspect of the tibial shaft such that it is slightly tapered (by approximately 1 2 mm) and the section should also be tapered towards the bone centre (see Figure 2) The graft should be reversed and one screw located distally to the compression device until the graft surface is level with the existing bone The graft is now secured to the distal fragment by both shear and compressive forces at the sawn surfaces A 4 mm diameter hole is then drilled in the graft approximately 10–15 mm from its



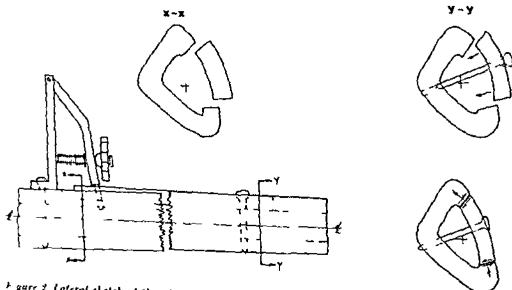


Figure 2 Lateral sketch of the tibia with the sliding bone graft in position before the application of compression at the fracture site The cross sections show the position of the graft in the distal and proximal ends of the shaft Photograph shows device in position just before compression is applied

Acta orthop scand 48 426–430 1977

PRELIMINARY REPORT OF A COMPRESSION TECHNIQUE TO APPLY TENSION TO SLIDING BONE GRAFTS IN TIBIAL SHAFT FRACTURES

R J Minns & P L Frank

University of Durham, Durham and Hope Hospital, Salford Lancs U K

A new compression device is described that applies tension to sliding bone grafts on the medial aspect of the tibia in tibial shaft fractures The mechanical aspects of the operation are outlined and the advantages and disadvantages of the system discussed There have been no complications and rigidity has been obtained in two clinical cases Mechanical tests in bending and torsion show that rigidity can be obtained without breaking the graft

Key words tibial shaft fractures, grafting, rigidity, reduction, fracture fixation

Accepted 23 iii 77

Sliding bone grafts for the treatment of tibial shaft fractures have been used during immobilization (Holden 1973), however, it is well known that applying tension across the fracture site by compression plating decreases the time to full union due to the increased rigidity this system affords (Anderson 1965, Harris 1965, Muller et al 1970, Lettin 1965) Applying tension to sliding bone grafts was therefore considered, as this may very well add rigidity to a well-established treatment for delayed or non-union The existing Muller compression device, however, is unsuitable for use with sliding bone grafts since the protruding lip on the movable leg stands clear of the surface and will not pass through the hole made in the cortex of the graft A new device was designed which would allow tension to be applied to a sliding bone graft, resulting in compression at the fracture surfaces

Description of device

The device consists of a fixed leg 8 0 cm in length and a movable leg which is pivoted by means of a small hinge at the top Approximately a third of the way up the fixed leg a ¼ inch U N F screw passes through a slot in the movable leg and is screwed through the fixed leg at right-angles A large movable knob is situated on the screw to allow the movable leg to rotate about the hinge, a weak spring causing the two legs to stay apart The lip on the movable leg is positioned below the level of the bone surface so as to engage into a hole drilled in the sliding graft Figure 1 is a view of the compression device

Mechanical aspects of the operational techniques

To obtain a greater surface area of contacting bone the graft should be sawn

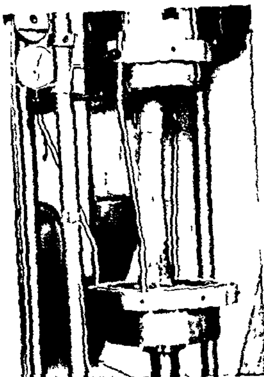


Figure 4 General view of the mechanical testing rig showing a tibia undergoing bending in the antero posterior plane

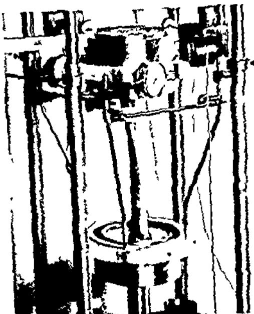


Figure 5 View of the mechanical testing rig showing a tibia undergoing a torsion test

rigidity. The technique of specimen preparation and testing procedures is described in Minns et al (1975) Bending was applied in the antero-posterior plane using the equipment shown in Figure 4, the deflections being recorded by a dial gauge situated at the distal end of the tibia Torsion was applied about the shaft axis as shown in Figure 5, two dial gauges recording angulation about the axis Three further tibiae were tested in which sawn artificially produced mid-shaft fractures were reduced by sliding bone grafting, the sliding graft being sawn from the antero-medial aspect

The bending and torsional stiffnesses of the tensioned sliding bone graft are low (see Tables 1 and 2) compared to unfixation [illegible] plates It may be true that a bending moment on the shaft introduced by tension applied to the graft using the device, placed within a cortex, is smaller than the one produced by a plate, placed on the subcutaneous side, but the bone is

Table 1 Results of bending tests on 17 tibiae used in conventional plating studies and three tibiae subjected to bending after experimentally applying a sliding bone graft to compress the two fractured surfaces The fracture was artificially produced by a saw cut (Units are Newton metres/millimetre deflection)

	Intact A/P	Intact M/L	Plated A/P	Plated M/L
Mean of 17 tibiae	6 16	3 72	3 09	1 69
Sliding bone grafts	5 07	3 42	0 65	0 40

Table 2 Results of torsion tests on the 17 control plated tibiae and the three sliding bone grafted tibiae (Units are Newton metres/degree angulation)

	Intact	Plated
Mean of 17 tibiae	4 40	1 96
Sliding bone grafts	2 72	1 71

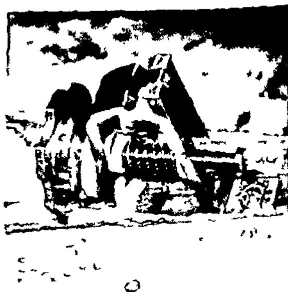
end to locate the lip on the movable leg of the compression device. The compression device is then attached by a 4 mm bone screw in the fixed leg and the graft should be raised above the bone surface so that on applying compression the two fracture surfaces approach each other with the opposite cortex contacting first so that equal compression will be applied when finally tightened (see Figure 2). Figure 3 shows the situation just prior to removal of the compression device. The two screws in the proximal fragment are angled towards the fracture so that when the compression device is removed, the tension in the graft is taken by these screws and will also bring the graft towards the centre of the bone (see section X–X, Figure 3) as there is now a slight gap due to the reverse taper.

Clinical experience

One of us (P.L.F.) has had the opportunity to insert two sliding bone grafts and they have withstood the tension without difficulty and compression was applied at the same time to the fracture site. The grafts have become incorporated and none of the screws used for fixation of the graft have had to be removed. The compression device described allowed the compression to be performed quickly without the use of additional equipment, as with other compression devices normally used for compression plating, the long stem allowing good purchase within the hole in the graft. The length of the stem also ensured that tension was applied parallel to the shaft of the bone, consequently causing even compression around the fracture cortex and not compression at an angle that would tend to open the graft and possibly break it.

Mechanical studies

Seventeen left tibiae were tested in bending and torsion to evaluate the effect of antero-medial plating on mechanical



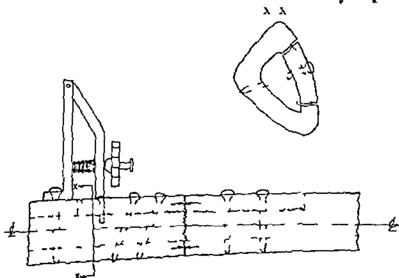


Figure 3 Position of the internal components after the application of compression just prior to removal of the device

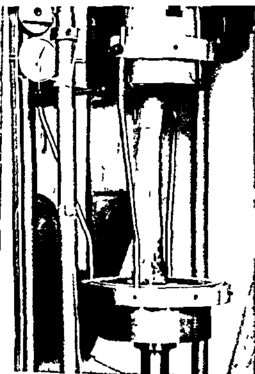


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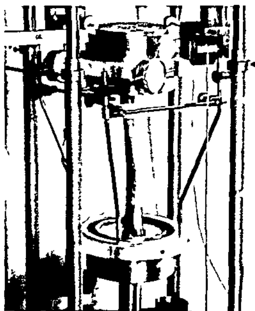


Figure 5 View of the mechanical testing rig showing a tibia undergoing a torsion test

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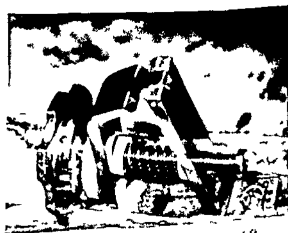
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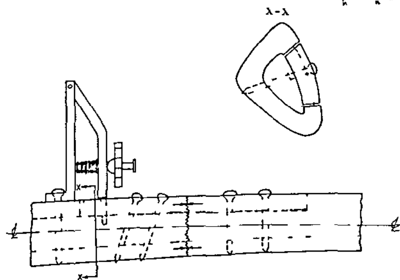


Figure 3 Position of the two tibial components after the application of compression just prior to removal of the device

Acta orthop scand 48 431–432 1977

STEN FRIBERG

IN MEMORIAM

Sten Friberg one of the pioneers and outstanding leaders in Scandinavian and international orthopaedics died in Spain on May 3rd 1977 A brief summary of his creative professional life will be appreciated by his contemporaries and friends and an inspiration to younger readers

Sten Friberg was born and raised in Stockholm After a comprehensive surgical and orthopaedic training he was appointed head of the orthopaedic service in Lund in 1941 and in 1943 he succeeded Henning Waldenström to the chair of orthopaedics at the Karolinska Institute in Stockholm



The scientific basis for orthopaedics in Sweden was laid down by Waldenström and Sten Friberg built further on this foundation In his department at Norrbacka in Stockholm he developed a comprehensive service for the disabled and promoted clinical and experimental research primarily concerned with hip and spine problems later with arthroplasties tumours and arterial reconstructions as well

He realized at an early stage that the traditional segregation of orthopaedics and traumatology had to be eliminated if further progress was to be made Accordingly he worked for recognition of a concept of orthopaedics expanded to include care of and research into disorders and injuries of the total musculoskeletal system This field was to be attended for by orthopaedic surgical wards in the teaching hospitals as well as in the county hospitals His political ability his firm though tactful approach and dedicated endeavours have been of great value in establishing today s general acceptance of orthopaedic surgery as an integral part of general hospital care in Sweden When he was appointed professor in 1943 his chair of orthopaedics was the only one in Sweden Today there are nine professors of orthopaedic surgery in Sweden and orthopaedic departments are to be found in all counties

His achievements in this respect also had a great impact on the other Scandinavian countries

many times less strong under bending than the currently available implant materials The torsional stiffness would be expected to be very much lower than that obtained in plated tibiae because the torsional strength of the bone as a circular tube is many times reduced by the fact that the circumference of the bone is slit open (Brooks et al 1970) However, some torsional rigidity can be obtained very close to plated tibiae even when applying a tensile stress to the bone below its fracture strength, possibly because the graft becomes continuous with the cortex at any section Obviously the technique is limited to fractures that have a sufficient length of graft available to *accommodate four screws* probably it must be longer than 15 centimetres

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CELL PROLIFERATION IN BONE MARROW AND THYMUS FOLLOWING SOFT TISSUE DAMAGE

O JOHNELL

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Earlier experiments by the author have shown that an increase in mitosis in bone marrow and thymus occurs after fractures and bone marrow aspiration In this paper it is shown that soft tissue damage causes a statistically certain increase in mitosis both in bone marrow and thymus after 1 day A possible explanation for this is liberation of a mitogenic kinin

Key words mitoses bone marrow thymus wound cell proliferation

Accepted 26 iv 77

Mitotic stimulation in rat bone marrow and thymus has been reported following standardized bleedings (Perris et al 1971) administration of parathyroid hormone (Perris et al 1967 Perris & Morgan 1976) and injection of calcium (Perris et al 1967) and kinins (Rixon et al 1971)

In fractures autoradiographic studies of the proliferative response of osteogenic cells in mice have shown a mitogenic effect of the osteoblasts in the fractured bone and to a certain degree even in the opposite bone (Tonna & Cronkite 1961 Hyldebrant et al 1974) In an earlier report by the author of this paper it was shown that after femoral and tibial fracture in growing rats the mitotic activity increases in the first 2 or 3 days in the opposite femoral bone marrow and in the thymus (Hulth & Johnell 1976) In order to look at the reaction from the bone marrow locally, we aspirated bone marrow from right femurs and found an increase of mitotic activity in the bone marrow of the opposite femur and in the thymus though to a slightly smaller extent than in the fracture group (Hulth & Johnell 1977) In the present study, the mitotic activity in bone marrow is investigated after damage to soft tissue

MATERIAL AND METHODS

Thirty one inbred Sprague Dawley rats weighing 100 and 120 g were used They were divided into a control group and a soft tissue damage group In the latter group under anaesthesia a dorsal incision approximately 3 cm in length was made over the lumbar spinal processes cutting through the skin and the muscles the skin being thereafter sutured The rats were kept in a cage and supplied with food *ad libitum* In the experimental group the animals were killed after 1 2 4 and 7 days

The rats were given two injections of colchicine each (0 2 mg 100 g body wt) intraperitoneally 6 and 3 hours before they were killed by an overdose of ether The reason for the two injections of colchicine was to prevent the escape of

Financial support was obtained from Herman Järnhardts Stiftelse

Many of those who now have the responsibility for orthopaedic surgical care, teaching and research in Scandinavia continue his work and try to build further on what Sten Friberg has created, they will always remember him with gratitude

Sten Friberg's talent for administration and his personal capacity were recognized by national and international organizations He was elected dean of the medical school and chairman of the Nobel committee During the years 1953–1969 he had to reduce his clinical work as professor and head of the department as he at the same time held the position of dean (rektor) of the Karolinska Institute For the Karolinska Institute this was a period of very expansive activity Sten Friberg, however, maintained his deep interest in his patients and in the development of research projects carried out by his associates and pupils Through his profound interest in teaching, his wish to guide and his ability to listen he also gained the appreciation and gratitude of the students

In 1951 he was congress president for SICOT and arranged a most successful congress in Stockholm, which a number of orthopaedic surgeons from all over the world will long remember In 1966 he was elected president of SICOT and during the triennium he invested great efforts in strengthening the society

Acta Orthopaedica Scandinavica will remember Sten Friberg with great gratitude Over a period of more than 20 years Sten Friberg was editor of our journal The position of Acta as an important international journal is essentially due to his vision and endeavours

Sten Friberg received numerous honours at home and abroad and he enjoyed the friendship of colleagues in all parts of the world

He was always faithfully supported by his dear wife, Gudrun, who also acted as a charming hostess to their mutual guests To Mrs Friberg and to the Friberg family we extend our deepest sympathy

Tor Hierton *Knud Jansen*

how bone and soft tissue trauma cause increased mitotic bone marrow activity

It has previously been shown that injection of bradykinin also causes an increased mitotic activity in bone marrow and thymus thus supporting the theory of mitogenic kinin In this experiment, it might be possible that mitogenic kinins are liberated from the trauma site, even though the parathyroid hormone might also be involved

It is impossible to say, at the present stage of the research what is the purpose if any, of the bone marrow cell proliferation after various types of trauma After haemorrhages, of course the bone marrow stem has to substitute the lost blood cells It is perhaps possible that the cellular response of the bone marrow has some important purpose in producing cells for migration into the fracture site or the soft tissue wound

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Correspondence to O Johnell Department of Orthopaedic Surgery Malmö General Hospital (University of Lund) Malmö Sweden

cells in metaphase from the initial block All animals were given the injections at the same time (the first injection between 8 and 8 30 a m) in order to avoid the circadian fluctuations in mitotic activity of bone marrow and thymus (Hunt & Perris 1973)

Groups of normal rats and rats after soft tissue damage were used for haematocrit determinations The thymus gland and the left femur were removed The thymocyte and bone marrow cell suspensions were prepared in a balanced glucose salts medium (5 5 mM glucose, 5 0 mM KCL, 0 63 mM $CaCl_2$, 1 0 mM $MgSO_4$ 5 0 mM $Na HPO_4$, 120 mM NaCl, 5 0 mM Tris buffer (pH 7 2)) The thymocyte suspension was prepared by mincing the gland in the medium with scissors, the resulting suspension being filtered through gauze To prepare the suspensions of bone marrow cells, the ends of the femurs were removed and the core of marrow was "washed out" with 1 5 ml of the medium and then dispersed by passing the tissue several times through a syringe with an 18-gauge needle Then both thymus and bone marrow suspensions were gently centrifugated

Samples of the cell suspensions were placed on slides immediately fixed in alcohol, and stained in haematoxylin eosin The slides were scored for the percentage of the total cell population in metaphase Each preparation had two slides and at least 500 cells were counted on each (a total of at least 1000 cells were counted) During the counting procedure the slides were labelled in code

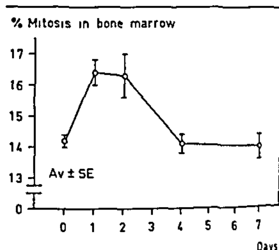


Figure 1 Percentage of total cells in metaphase in bone marrow from the left femur after colchicine injection

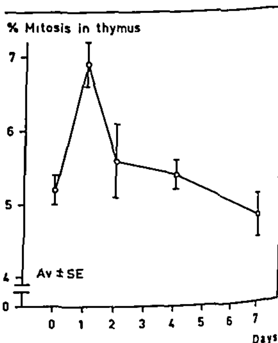


Figure 2 Percentage of total cells in metaphase in thymus after colchicine injection

RESULTS

In the soft tissue damage group, the mitotic activity was increased in the bone marrow cell suspension from the left femur 1 day after the trauma ($0.1 > P > 0.001$), returning towards the normal value (Figure 2) The haematocrit The thymus cells, arrested in metaphase, increased 1 day after the damage ($P < 0.001$) and then returned to the normal value (Figure 2) The hematocrit did not differ from the control animals in the experimental group

DISCUSSION

Various types of trauma seem to increase bone marrow and thymic cell mitotic activity This is valid not only for standardized bleedings (Perris et al 1971) and fractures (Hulth & Johnell 1976) but also for slight trauma such as bone marrow aspiration (Hulth & Johnell 1977) In this paper it is shown that a soft tissue incision gives the same result The mitotic activity after bleeding is governed by the parathyroid gland but it is not certain

originating from surface cracks during testing the machining was done lengthwise on an automatic lathe.

The samples were then tested in bending to rupture in a Zwick Z 1–3D test rig. The samples were loaded centrally with a deformation speed of 6 mm per minute. The modulus of elasticity (Young's modulus), hereafter called E modulus, was determined from two readings on the ascending part of the curve obtained. The E modulus was calculated from the readings using a nomogram constructed for the purpose according to the formula

$$F = \frac{L^3}{4 \times bh^3} \times \frac{\Delta F}{\Delta \lambda} \text{ kp/cm}^2$$

(Weast 1968)

l = distance between supports
b = width of sample
h = height of sample
Δ F = increase of blood
Δ λ = deformation

The samples were then further loaded until rupture and the flexural stress was read directly from the graphs obtained from the test rig. The flexural strength was calculated from the formula

$$S_{max} = \frac{3}{2} \times \frac{F_{max} \times L}{b \times h^2}$$

F_{max} = stress at rupture

The experiments were made at room temperature (22° C). However, E modulus and flexural strength were also determined at 38° C for all three brands of cement. CMW and Simplex P were tested without any additions but Palacos was only available as Palacos R® i.e. with Zirconiumdioxide as radio-opaque substance already added. CMW was tested with the addition of 2.5 and 5 g of barium sulphate as indicated by the manufacturer while Simplex was tested both pure and in the form of Surgical Simplex R Radioopaque® which also contains $BaSO_4$. Macroscopically the $BaSO_4$ was difficult to distribute evenly in the CMW. There was a tendency for small clumps of the substance to stick together and they were visible on the surface of the test samples. All brands of cement were tested with gentamicin added as this anti bi[illegible]
ad[illegible]
pre[illegible]
[illegible] package of each brand was prepared and tested after the gentamicin had been washed out at body temperature in human plasma as indicated by Holm & Vejlsgaard (1976). Also the three types of cement were tested for possible changes of values due to afterpolymerization. Samples were tested 8 h after mixing and others at 24 h and 1 week after initial polymerization. All other samples were stored for at least 3 weeks at room temperature to eliminate any effect of afterpolymerization on the results. A total of 376 tests were made.

RESULTS

E-modulus

The measured values were treated statistically by parametric variance analysis and the Student-Newman Keul procedure. These analyses showed for all types of cement that the variation between the eight determinations of E-modulus obtained from each portion of cement was significantly smaller than the variation between the portions of cement prepared in different ways ($P < 0.01$). The standard deviations of the eight measurements per package were for CMW 1.54, for Simplex P 1.16, and for Palacos R 1.15. Standard deviations between different portions of cement were two to four times larger.

The values of the E-moduli in each type of cement fell into 3–5 groups that were significantly different whereas the values within each group did not differ significantly from each other. In the case of CMW the groups were not sharply delineated statistically speaking, but overlapped somewhat. This means that for some factors significant differences cannot be demonstrated with certainty, however indicative tendencies were found. Where percentages are given in the following they are only to be taken as approximations. Mean values are given in Table 1.

For CMW the E-modulus calculated from the results for the portions of cement without additions was found to be 26 000 kp/cm², Simplex P showed a value of 24,600 kp/cm², and Palacos R (Zirconium dioxide added) was found to have an E-modulus of 23,900 kp/cm²

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THE MODULUS OF ELASTICITY AND FLEXURAL STRENGTH OF SOME ACRYLIC BONE CEMENTS

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The modulus of elasticity and flexural strength were measured for three bone cements, CMW Bone Cement, Surgical Simplex and Palacos R with various additions and prepared as in actual use A distinct afterpolymerization was demonstrated in all three brands The addition of blood lowered the E modulus whereas radio opaque media seemed to render them somewhat stiffer The rupture values demonstrated the inhomogeneity of the final product in all three brands The possible clinical significance of the findings is discussed

Key words bone cement, E modulus, flexural strength

Accepted 21 v 77

The use of polymethylmethacrylate as a means of fixation of total joint replacements has become an established procedure The present study was intended as a contribution to the understanding of the nature of some of the bone cements available A comparative study of variations in the modulus of elasticity and the flexural strength as a result of the addition of various substances was carried out as a preliminary analysis

MATERIAL AND METHODS

In order to get an impression of the physical characteristics of the substance as used in surgery, it was decided to use a preparation technique resembling as closely as possible that of actual use i e manual mixing stirring and handling Three brands of cement were tested CMW Bone Cement® Surgical Simplex® and Palacos R® All test samples were prepared from packages from the same production batch as indicated by the numbers on the packages The cement was in each case mixed according to the instructions of the manufacturer described in the directions accompanying the packages In each case a whole package of bone cement powder (40 g) and a vial of monomer of about 20 g were mixed All additions of dry substance ie $BaSO_4$ or gentamicin were made to the powder and mixed well with this before adding the liquid monomer

As it is not possible to measure the amount of blood added to cement during actual use in surgery it was chosen to investigate the effect of the addition of two quantities 1 ml and 3 ml of heparinized whole blood to the cement The amount of blood was measured with a standard injection syringe the blood was added to the cement as soon as the powder monomer mixture had become liquid and was mixed into the cement by stirring It was possible to mix the blood into the cement quite evenly without stirring more vigorously than usual

After mixing the cement was pressed manually into an open mould The mould was closed and held together with clamps during polymerization in order to obtain complete filling of the mould Each package yielded eight test samples measuring $4 \times 10 \times 110$ mm After polymerization the test bodies were removed from the mould and excess cement was machined off so as to obtain the exact thickness of 4 mm In order to minimize the risk of early rupture

[illegible] determinations per package of [illegible] Where a time factor [illegible] merization and test [illegible]

Addition	CMW	Simplex	Palacos R
None 8 h	573 (448)	520 (365)	614 (504)
None 7 days	678 (562)	547 (381)	601 (558)
None, 3 weeks	612 (500)	564 (503)	488 (454)
do	593 (554)	702 (432)	684 (686)
$BaSO_4$, 2.5 g	599 (409)	503 (299)	
do	544 (395)	577 (386)	
do	594 (396)		
do	592 (430)		
$BaSO_4$, 5.0 g	565 (408)		
do	495 (318)		
do	513 (425)		
Gentamicin 1.0 g	600 (394)		
do	671 (616)		
Gentamicin 0.5 g		533 (458)	607 (486)
do			647 (498)
Blood 1 ml	691 (476)	640 (537)	636 (600)
do	700 (540)	659 (601)	719 (604)
Blood 3 ml	427 (268)	595 (482)	561 (419)
do	519 (337)		644 (516)
Gentamicin eluted	650 (587)	476 (395)	571 (523)
None, 37° C	673 (550)	381 (259)	506 (420)

When standard deviations of several portions prepared in the same manner were compared, deviations of as much as 17 to 20 per cent were found. Macroscopic examination of the test samples after rupture showed that in some cases breaking had not taken place in the middle of the sample, i.e., in the area of maximum deformation, but somewhere off to the sides. Occasionally a sample might shatter into three or four fragments indicating high and unevenly distributed intrinsic stresses in the sample. Examination of the rupture surface often revealed extra large air bubbles, grains of radio-opaque material or other obvious reasons for local weakening. For this reason only mean and minimum values of flexural strength are indicated in Table 2 in order to demonstrate the order of magnitude of the limiting factor in the load sustaining capacity of the cements.

DISCUSSION

It has been more or less assumed that methylmethacrylate bone cements are rather well defined substances, but differences in handling characteristics seem to indicate that there might be quite substantial differences in mechanical properties depending on the manufacturer and the various additives. Since Charnley did the pioneering work on bone cements in the sixties and published his monograph describing some of the physical properties of CMW bone cement (Charnley 1970), several other investigators have evaluated the physical and chemical aspects of methylmethacrylate cement from a surgical point of view. Methylmethacrylate as used industrially is in each case a rather uniform product, usually heat polymerized and machine mixed. This is not so in surgery. Bone cement consists of polymethylmethacrylate powder plus a liquid consisting of methylmethacrylate monomer. The pow-

The E-modulus showed a statistically significant increase for all three brands during the first week after polymerization as indicated by the values obtained at 8 hours, 24 hours, and 1 week after initial polymerization. The increase amounted to 5 per cent for Simplex, 7 per cent for CMW, and 8 per cent for Palacos.

Table 1. Modulus of elasticity, mean values of eight determinations per package of cement ($n \times 10^3$ kp/cm²)

Addition	CMW	Simplex	Palacos R
None, 8 h	24.4	23.8	22.2
None, 24 h	25.9	24.2	23.8
None, 7 days	26.5	25.3	24.4
None, 3 weeks	26.7	24.1	24.4
do	25.3	24.4	23.1
$BaSO_4$, 2.5 g	28.0	25.1	
do	27.0	26.7	
do	27.4		
do	29.8		
$BaSO_4$, 5.0 g	26.3		
do	25.6		
Gentamicin, 1.0 g	26.9		
do	25.5		
Gentamicin, 0.5 g		22.5	23.9
do			23.9
Blood, 1 ml	21.8	25.6	25.3
do	23.9	26.7	24.3
Blood, 3 ml	20.1	24.1	23.3
do	20.8		23.2
Gentamicin eluted	23.0	23.6	23.3
None 38° C	26.9	24.7	22.5

Adding 2.5 g $BaSO_4$ to one portion of CMW increased the E-modulus in all tests though only one test showed values that were with certainty statistically increased (about 10 per cent). The radio opaque Simplex also showed a tendency towards greater stiffness than the pure preparation, but only one determination was significantly increased (8 per cent).

Adding blood to CMW decreased the E-modulus, 1 ml of blood caused a decrease of about 12 per cent. This change was further augmented by adding 3 ml per portion, a decrease of 21 per cent giving the lowest value recorded in the series. In the case of Simplex, the results were somewhat different, showing a slight increase in the E-modulus after addition of 1 ml of blood, but the values are only statistically significant in one case. Adding 3 ml of blood again gave lower values. In the case of Palacos R the results of adding 1 and 3 ml of blood fell into separate statistical groups, the smaller amount of blood showing no change of E-modulus whereas the larger amount decreased the E-modulus by about 3 per cent which is statistically significant.

Adding a soluble substance such as gentamicin sulphate to CMW in an amount of 1 g per portion of cement tended to decrease the E-modulus a little though the values are not statistically significant, but when the antibiotic had been washed out the E-modulus decreased about 11 per cent, this figure being statistically significant. Surgical Simplex showed a similar pattern with a decrease in E-modulus of about 8 per cent in spite of the fact that only 0.5 g of gentamicin was added in this case. Refobacin-Palacos R showed values 5 to 6 per cent lower than Palacos R. The elution of the gentamicin from Simplex and Refobacin-Palacos R did not result in any further significant decrease of E-modulus.

The increase of ambient temperature to 38° C gave slightly lower values, but only in the case of Palacos R was the difference statistically significant, about 6 per cent.

Flexural strength

The values of flexural strength, i.e., the maximum stress at rupture of the test sample (expressed in kp/cm²) were widely scattered. Standard deviations within the groups of eight samples originating from the same portion of cement varied from 4.1 per cent to 10.6 per cent

tact area This greatly increases the stability of the prosthesis (Charnley 1965a)

During activity when a prosthesis is put under stress an elastic deformation of all components involved takes place at each step The magnitude of this deformation is dependent on the E modulus of the substance involved the smaller the E-modulus the greater the deformation It is therefore obvious that when two substances of different E moduli in contact with each other are put under stress in a direction parallel to their common surface as is the case with cement in contact with bone on one side and the femoral prosthesis on the other movement will take place between them because one substance will show greater deformation than the other The phenomenon is called fretting and has been described by Charnley (1965) in relation to the anchoring of the femoral stem of the total hip replacement Charnley considers the cement to be an integral part of the prosthesis This cannot be entirely true as the cement and the metal of the prosthesis have greatly different E moduli As blood and soluble and insoluble additions to the cement may be unevenly distributed throughout the cement the substance will show varying elastic deformations throughout its volume thereby putting greater stress on stiffer areas The results of the breaking tests where the samples in some cases shattered show that uneven polymerization may give rise to intrinsic stresses in the cement and such pre-stressed areas further complicate the pattern of stress and deformation throughout the cement The inclusion of air bubbles and vacuoles from dissolved substances will form critical points of weakness from which cracks in the cement may originate It is thus not uncommon to find fractures of the cement in cases of prosthetic loosening in the absence of infection Charnley reports such a case in his monograph of 1970 An increased risk of mechanical failure might for the same reasons be encountered in the cement protrusions that interlock with the bony trabecula causing microfractures of either bone or cement and hence loosening

The most important conclusion must however be that the mixing and the method of application of the cement is the most important factor as regards the strength of the final product In spite of the fact that careful preparation of all cement was carried out according to the instructions of the manufacturer the end result was extremely inhomogenous and demonstrated how different even portions of the same manufacturing batch may turn out in actual use The very large standard deviations of the breaking tests with considerable variation even within the same portion of cement underline the problems It is therefore concluded that careful stirring and mixing of ingredients is important if ready mixed preparations are not used It must be considered of importance to have as dry an operating field as can be obtained so as to avoid the decrease in E-modulus resulting from the addition of blood The use of a cement syringe as advocated by Slooff (1973) would seem a reasonable procedure in order to obtain as homogeneous a cement as possible

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der contains an initiator, usually benzoyl peroxide and $BaSO_4$ or ZrO as radio-opacifier and may contain copolymers such as styrene or butylmethacrylate to improve handling (Lautenschlager et al 1974) The monomer contains a catalyst, mostly tertiary amines, and a stabilizer such as hydroquinone The cement is mixed manually with a spoon or spatula in a bowl, and polymerization depends on an even distribution in the mixture of catalyst and oxidizer A varying amount of air is added during the process yielding a very heterogenous substance which is further kneaded, folded and mixed with blood during application It is not surprising that one often notices that the cement still may be soft in places while other parts have already become hard as an indication of uneven polymerization This study was aimed at illustrating the variations in physical properties as encountered in surgery and this is the reason why the cement was handled as it is in actual use

The first question raised by this investigation is the difference between the E-modulus of Palacos R found in the present results and that indicated by the manufacturer in the brochure included in the cement package (15,500 kp/cm) The values found in the present investigation correspond well with those of other brands of polymethylmethacrylate investigated and are of the same order of magnitude as values commonly indicated for other commercially available acrylics However, the values indicated by Buchholz & Engelbrecht (1970) correspond well with the values of the manufacturer Personal correspondence with the manufacturer (Kulzer & Co) has given no answer to the question

An increase in the E modulus occurred during the first week This must be interpreted as the effect of afterpolymerization and is caused by an increase in length of the molecular chains and possibly also the polymerization of about 3 per cent of the monomer not polymerized immediately (Haas et al 1975, Feith 1975, Charnley 1970) With CMW the addition of radio-opacifier is done by stirring the $BaSO_4$ powder into the cement powder It seemed difficult to distribute the $BaSO_4$ evenly in this way and there was a tendency for small clumps of the substance to stick together These were visible as little white specks on the surface of the samples This was not the case with the two other brands where the cement and the radio-opacifier are mixed by the manufacturer The reduction of E-modulus in CMW mixed with 5 g of $BaSO_4$ cannot be explained with certainty, but it is possible that with increasing amounts of $BaSO_4$ this substance begins to act as a filler and causes a decrease in the amount of acrylic present in the cross section of the test sample

It is a common experience that cement hardens more quickly when mixed with blood, but the results show a smaller value for the E-modulus which must indicate a lesser degree of polymerization This could be due to interaction of blood enzymes (catalase?) with the peroxides of the cement, breaking these down so fast that the necessary free radicals to complete polymerization are no longer available The decrease in E modulus after the washing out of gentamicin of the cement is in accordance with Grunert & Ritter (1974), who found a change in E-modulus of about 8 per cent, whereas Buchholz & Engelbrecht (1970) found no change in their investigation However their values are as low as 16 500 kp/cm² As regards temperature sensitivity, the slight decrease of the E-modulus at 38° C is to be expected with a thermoplastic substance like polymethylmethacrylate

The importance of using acrylic cement as a means of fixation in total joint replacement lies in the function of the cement as a filler between bone and prosthesis thereby distributing load and stresses more evenly over the entire con-

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CHANGES IN BONE FORMATION DURING IMMOBILIZATION AND DEVELOPMENT OF EXPERIMENTAL OSTEOARTHRITIS

A Study using Oxytetracycline in Rabbits

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The effect of immobilization on bone formation in the knee and hip was studied by means of oxytetracycline One leg of 11 growing and 13 adult rabbits was immobilized so that the knee was held in extension but the hip was free In the knee degenerative changes developed consistently with a severity proportional to the length of the immobilization time In most of the rabbits given oxytetracycline 1 13 days before they were killed considerably more oxytetracycline was incorporated in the bone in the immobilized knee region and slightly more in the hip region of the same leg than in the corresponding areas of the other leg This indicates an increased turnover of bone tissue in the immobilized leg compared with the non immobilized leg

Key words bone formation, experimental immobilization osteoarthritis tetracycline

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Degenerative joint changes have been produced experimentally in animals by various methods for instance, prolonged compression (Salter & Field 1960, Trias 1961) induced *instability* (*Telhag & Lindberg* 1972) or immobilization of the joint in flexion or extension (Evans et al 1960 Hall 1963 a b) Immobilization of the knee in extension in young rabbits consistently causes deformities of the hip Michelsson & Langenskiöld 1972 a b Michelsson & Langenskiöld 1974) In adult rabbits immobilization of the knee in extension for 6 weeks or more results in every case in degenerative changes in the knee and in some cases also in the hip (Langenskiöld et al 1975, Videman et al 1975 Michelsson et al 1977, Videman et al 1977 a, b)

When oxytetracycline is administered to a rabbit, a part of the antibiotic becomes bound to the bone tissue Deposition of oxytetracycline in bone is associated with the ossification process (Milch et al 1957) 'Adventitious' tetracycline disappears from the bone 2 days after the administration of the antibiotic and the residual antibiotic in newly-formed bone disappears only through resorption of bone (Frost et al 1960) As tetracyclines fluoresce in ultraviolet light (Saltzman 1950), they can be used as bone labels The tetracycline technique is a valuable supplementary aid in the

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Degenerative joint changes have been produced experimentally in animals by various methods for instance, prolonged compression (Salter & Field 1960, Trias 1961), induced instability (Telhag & Lindberg 1972), or immobilization of the joint in flexion or extension (Evans et al 1960 Hall 1963 a, b) Immobilization of the knee in extension in young rabbits consistently causes deformities of the hip (Michelsson & Langenskiöld 1972 a, b, Michelsson & Langenskiöld 1974) In adult rabbits immobilization of the knee in extension for 6 weeks or more results in every case in degenerative changes in the knee and in some cases also in the hip (Langenskiöld et al 1975, Videman et al 1975, Michelsson et al 1977, Videman et al 1977 a, b)

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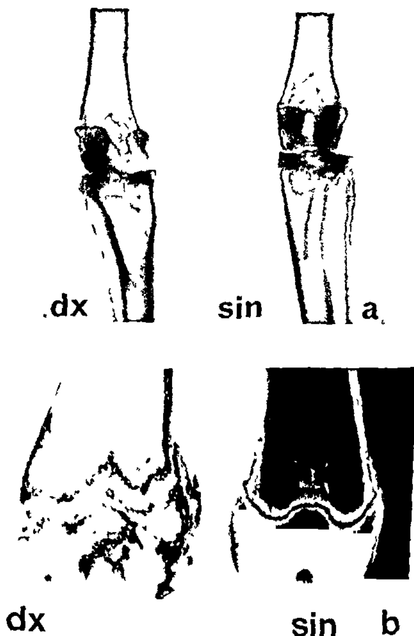


Figure 1 a, b A 3-month old rabbit (29) was immobilized with the right knee in extension for 5 weeks Oxytetracycline was given before it was killed at the age of 6 months Deformation of the right knee had developed a) Radiograph taken of specimens b) In the specimen of the distal end of the right femur a deformed thickened epiphyseal plate with oxytetracycline labelled bone on both the metaphyseal and epiphyseal sides is visible

study of the bone formation occurring during immobilization

In this study oxytetracycline was used to investigate new-bone formation in the knee and hip regions in rabbits in connection with immobilization of the knee and the development of osteoarthritis

MATERIAL AND METHODS

Eleven growing rabbits 2 5 months old and 13 *adult* rabbits aged 9 33 months made up the *experimental* series The right hind limb of the rabbits was immobilized with a plastic splint and Tensoplast® so that the knee remained in extension but the hip was free and movable A corresponding technique for immobilization has previously been described in detail (Michelsson

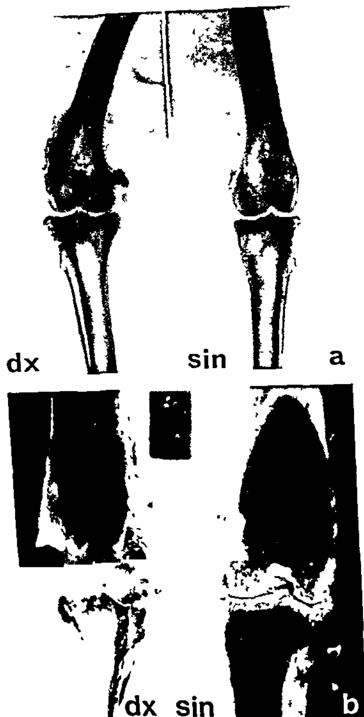


Figure 2 a, b. An adult rabbit (401) was immobilized with the right knee in extension for 7 weeks before it was given oxytetracycline and killed. a) Marked degenerative changes of the right knee had developed and are visible on the radiograph. b) In the specimen from the right knee the amount of oxytetracycline labelled bone was considerably greater than in the left knee (b)

Table 1 Content of oxytetracycline in knee and hip of the immobilized (right) leg compared with the left non immobilized knee and hip in 20 rabbits The oxytetracycline was given some days before the animals were killed

Rabbit no	Age at immobilization in months	Duration of immobilization in weeks	Interval between immobilization and sacrifice in weeks	Oxytetracycline content in right knee	Oxytetracycline content in right hip
Growing rabbits					
295	3	5	8	++	+
411	3	6	1	++	+
412	3	6	1	+	++
220	4	6	28	+	+
221	4	6	30	++	+++
398	5	6½	0	+	+
387	5	7	0	+++	+
389	5	7	2	++	+
388	5	8½	½	++	+
392	5	8½	2	++	++
225	2	13	1	++	+
Adult rabbits					
395	> 12	2	1	+	+
66	12	4	52	+	+
80	9	5	78	—	—
401	> 12	7	0	+++	+
10	> 12	8½	52	+	—
375	13	13	34½	+	—
230	33	13	26	++	—
89	11	17½	1	—	—
303	16	17½	2	++	+

— not more oxytetracycline in the right (immobilized) joint than in the left
\+ slightly more oxytetracycline in the right (immobilized) joint than in the left
++ moderately more oxytetracycline in the right (immobilized) joint than in the left
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& Langenskiöld 1972 b Michelsson & Langenskiöld 1974)

The splint was removed after 2 17½ weeks and the animals were allowed to move freely

The animals were killed 0 78 weeks after the immobilization period having been given 50 mg oxytetracycline per kg of body weight intramuscularly on three consecutive days Nine adult and all the 11 growing rabbits were given the oxytetracycline injections 1–13 days before they were killed (Table 1) Four other adult rabbits were given oxytetracycline at the beginning of immobilization and were killed 49 90 days thereafter

The hips and knees of the animals were dissected split in the frontal plane and examined in UV light The knees and hips of the immobilized and non immobilized legs were compared principally with regard to their oxytetracycline content

RESULTS

In 18 of the 20 rabbits that received the oxytetracycline just before they were killed, the oxytetracycline content was higher in the bone tissue of the knee and in 15 of them also in the hip of the immobilized (right) leg than in the corresponding joints of the other leg (Table 1)

In *the growing rabbits* the condyles of

the immobilized *knee* were wider than normal, their structure was more heterogeneous and they were deformed Higher concentrations of oxytetracycline were found on the immobilized side compared with the normal knee and it was always found to be spread over larger areas In the distal end of the femur of growing rabbits there is normally a tetracycline marked zone only on the metaphyseal side of the epiphyseal plate, but in the immobilized leg in three rabbits there was bone marked by tetracycline on the epiphyseal side as well (Figure 1 a b)

In *the adult rabbits* marked degenerative changes were seen in the immobilized *knees* The condyles were thicker than normal slightly deformed and their structure was more heterogeneous than normal Oxytetracycline was found over larger areas especially at the periphery, and in general in higher concentrations than in the left knee (Figure 2 a, b) These changes occurred in seven of the nine rabbits given oxytetracycline just before they were killed In two of the four adult rabbits given oxytetracycline at the beginning of the immobilization period only, the oxytetracycline content was higher in the left knee than in the immobilized right knee

Marked changes were also seen in *the hip joints* of the immobilized hind legs of the rabbits the capsule was considerably thickened and the cartilage had degenerated The cartilage and bone alterations were generally less severe than in the knee joints In some hips however, noticeable alterations were seen in the head and neck of the femur, where the oxytetracycline content was also higher and covered larger areas than in the hip joint of the non immobilized leg (Figure 3 a b) These changes occurred in 15 of the 20 rabbits given oxytetracycline 1 13 days before they were killed In two of the three rabbits examined and given oxytetracycline at the beginning of the immobilization period the oxytetracycline content was higher in the left hip than in the right

DISCUSSION

In which tissues and at what time the various alterations take place when osteoarthritis develops has not been satisfactorily explained Since it is difficult to study the initial stages of osteoarthritis in humans studies of experimentally induced arthritis in animals have been commenced In the studies of other investigators, experimental osteoarthritis has mostly been produced by trauma and has therefore been accompanied by tissue damage In this series immobilization was used in order to produce osteoarthritis without immediate tissue damage In our experiments the knee only was immobilized in extension while the hip was left free Degenerative alterations were consistently produced in the knee as a direct consequence of immobilization, but also in the hip of the same leg marked degenerative alterations were sometimes seen even though it was not immobilized

We have previously reported that in adult rabbits knee immobilization simultaneously increases the uptake of ^{35}S-sulphate in the joint capsules of the knee and hip, and in the cartilage and bone tissue (Videman et al 1975, 1976) The oxytetracycline content was usually higher in the right immobilized knee and hip in the rabbits given oxytetracycline just before they were killed, but in the non immobilized knee and hip of the rabbits given oxytetracycline at the beginning of immobilization This indicates an increased turnover of the bone tissue in the immobilized leg compared with the other leg

This study increases our understanding of how bone tissue reacts during immobilization and the development of osteoarthritis

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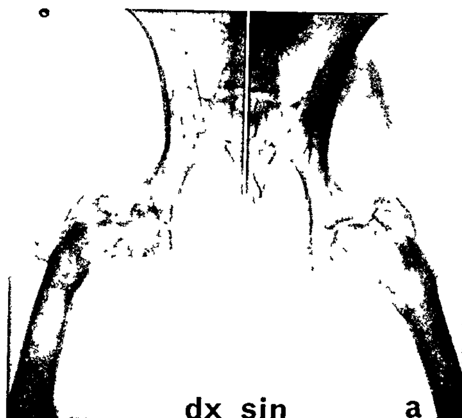




Figure 3 a b. A 4 month old rabbit (223) was immobilized with the right knee in extension for 6 weeks. Seven months later the animal was given oxytetracycline and killed. a) Degenerative changes are clearly visible on the radiograph of the right hip. b) Increased content of oxytetracycline as a sign of increased bone formation in the specimen of the right hip.

Table 1 Pre- and postoperative data of the 31 patients

Case	Age	Side	Etiology and duration of ankylosis (years)		Range of motion (extension flexion) Initial	3 months after operation	At the time of follow up	Evaluation	Length of follow up (years)
1	15	r	Fracture	7	50	30-105	30 105	Good	5
2	19	r	Tuberculous	17	65	45-87	60	Poor	17
3	36	l	Fracture	5	70	50 115	50-135	Good	16
4	25	r	RA	8	90	35-105	15 145	Excellent	7
5		l			80	30-110	20-140	Excellent	7
6	21	r	Dislocation	11	50	50-100	60-95	Poor	23
7	50	r	Fracture	2 months	55-80	50-100	20 115	Excellent	21
8	25	r	RA	4	10 50	30 115	60	Poor	20
9	50	r	Typhoid	20	45-70	60-70	70	Poor	10
10	23	r	Tuberculous	10	80	65 110	65 110	Fair	22
11	20	r	Fracture	15	40-90	35-105	50-90	Fair	22
12	22	r	Osteomyelitis	11	5	35-80	40 120	Good	24
13	40	l	Gonococcal	25	30	25-85	30-90	Fair	18
14	29	r	Dislocation	1	65-70	65-100	55-115	Fair	30
15	32	r	Fracture	11	45 65	60-100	50-90	Fair	24
16	40	r	Purulent	22	40	50-100	55 110	Fair	27
17	19	r	Purulent	8	90	65-82	85	Poor	25
18	42	l	Fracture	4 months	87	30-130	20 110	Excellent	28
19	41	r	Gonococcal	10	45	25-50	35-50	Poor	28
20	15	l	Fracture	5	50 70	20 110	60-115	Fair	30
21	33	r	Fracture	2	50	35 100	30-110	Good	31
22	22	r	RA	8	60	35-110	20 110	Excellent	9
23		l		7	55	35-120	30 120	Excellent	9
24	21	r	RA	5	50-60	35-95	30-100	Fair	10
25	32	r	Dislocation	3	20	40-70	15-90	Good	11
26	34	r	Dislocation	3	20	20-90	20-125	Excellent	9
27	32	r	RA	5	30	30-120	30-120	Excellent	9
28	15	l	Fracture	5	40-80	50-100	40-110	Good	25
29	18	r	Fracture	4	65	65-90	60-100	Fair	26
30	12	r	Fracture	4	50	60-75	60-100	Fair	23
31	20	r	Osteochondromatosis	3	20 85	50-130	40-130	Excellent	22
Average	27			8	50-59	42 102	43-105		19

30*

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ARTHROPLASTY OF THE ELBOW USING J-K MEMBRANE

An Analysis of 31 Cases

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A study of the end results of arthroplasty of the elbow has been made 31 cases were evaluated clinically and roentgenographically an average of 19 years after operation The arthroplasty was performed with a minimum of bone resection using chromicized fascia lata (J K membrane) as an interposition The maximum range of motion was regained within 3 months and was maintained during the follow up period No patient in this series suffered from pain or instability of the joint though radiological signs of osteoarthritis were common

Key words arthroplasty of the elbow, J-K membrane

Accepted 7 vi 77

Restriction of movement and pain in the elbow joint are a cause of disability at work and limitation of daily activity Arthrodesis is unsatisfactory from the functional and cosmetic points of view

Various arthroplastic procedures have been devised in an attempt to improve these conditions, since the first success of Verneuil (1860), and the subsequent description of the principles of arthroplasty by Ollier (1885), Murphy (1913), and Campbell (1931) Due to the rapid development of the various types of endoprostheses, classical methods of arthroplasty have been abandoned in recent years Nevertheless, the elbow still remains the joint most suited for arthroplasty without a prosthesis, because it bears little weight and the pattern of movement is relatively simple

In Japan, Sumita (1912) carried out experimental studies on arthroplasty and Jinnaka & Kono (1949) utilized chromicized autogenous fascia (named J-K membrane) as an interposition They succeeded in diminishing the inflammatory tissue reaction of Baer's membrane (1918) by reduction of the dichromic acid potassium under direct sunlight and washing off of the soluble chromic oxidase

The purpose of the present analysis is to evaluate the long-term results as regards 1) range of motion 2) functional ability 3) severity of neurological complications and 4) roentgenographic changes, in a series of this type of arthroplasty

PATIENTS AND METHODS

Details of the 31 patients in this series are listed in Table 1 There were eight cases of septic arthritis fifteen cases of fracture or fracture-dislocation and seven cases of rheumatoid arthritis.

1) *Preparation of J K membrane*

One week before operation, a sheet of fascia 8 × 6 cm is detached from the tensor fascia lata

Table 2 The results of arthroplasty of the elbow classified according to the various etiologies

Etiology	Excellent	Good	Fair	Poor	No of cases
Fracture and or dislocation	3	5	6	1	15
Septic arthritis		1	3	4	8
Rheumatoid arthritis	5		1	1 *	7
Osteochondromatosis	1				1
Total	9	6	10	6	31

Case 8



Figure 9 Case 9 Rheumatoid arthritis a) before b) 2 months and c) 9 years after operation

dication for this type of arthroplasty Herbert 1958 Hurri et al 1964)

As a general rule the maximum range of motion was regained within 3 months after the operation and this remained unchanged as time passed Bone resorption was rarely seen in our patients Proliferative or hypertrophic bone changes were found quite frequently but never to such an extent that pain or progressive limitation of motion could be attributed to them There were no cases of serious instability or subluxation Pseudoarthrosis of the olecranon was found in four cases but the force of extension was not diminished

Air arthrography was performed in four cases The joint cavity had almost normal dimensions (17 5 ml on average) and was bounded by an irregular capsule

muscle of the patient The fascia is stretched on a frame and kept in a 2 per cent dichromic acid potassium solution at room temperature for 24 hours Following this it is exposed to direct sunlight or a quartz lamp for 1 or 2 days in order to reduce the dichromic acid The fascia is then washed in running water for 24 hours Afterwards it is stored in phenol with the addition of 70 per cent alcohol

2) *Operative technique*

A posterior approach is preferred The olecranon is cut and reflected A simple monocondylar joint is fashioned by resection of a minimum amount of bone in order to avoid postoperative instability The humero ulnar joint is reshaped according to the anatomical curvature The radial head is usually resected at the same level as the ulna In nine cases reshaping of the radial head was done in order to preserve the pronation supination of the forearm In four cases transposition of the ulnar nerve was performed

The coronoideal and olecranon fossae are deepened and the end of the humerus is covered by the J K membrane Lengthening of the triceps tendon is rarely necessary even when the elbow is ankylosed in full extension

3) *Aftertreatment*

The extremity is immobilized for 1 week following which an extension frame is applied (Figure 1) Three weeks after operation pulley exercises are begun in the frame with mild resistance both active and passive

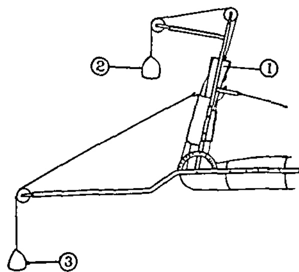


Figure 1 Traction pulley exercise apparatus
1 Skin traction on forearm
2 Weight for traction of forearm
3 Weight for flexion exercises of the elbow

RESULTS

The end results have been graded as follows

Excellent range of motion from 90 to 120°, with good stability and muscle strength

Good range of motion from 70 to 90 with satisfactory stability and sufficient strength for everyday activities

Fair range of motion from 40 to 70 without instability, or adequate range of motion with instability

Poor range of motion less than 40 and/or gross instability

The results classified according to the various etiologies are shown in Table 2

In 15 cases of fracture and fracture dislocation one failure was due to postoperative infection The results were very diverse in this group perhaps because the deformity of the humeral condyle makes it difficult to judge the optimal amount of bone resection Soft tissue damage following open fracture is also an undesirable factor

The results in eight cases of septic arthritis were almost entirely unsatisfactory Only one case was evaluated as good

Among seven cases of rheumatoid arthritis one failure was due to fracture of the humerus 5 months after the operation (Case 8) The elbow was immobilized for 2 months as a consequence of which bony ankylosis developed Apart from this case the results for this condition are most encouraging in spite of extensive joint involvement (Figure 2) The disease was quiescent at the time of operation and no exacerbation of the arthritic process followed Arthroplasty of both elbows was performed in two patients and the results were satisfactory Less resorption of bone was found in the rheumatoid cases in comparison to the other groups In general rheumatoid arthritis was considered to be the best in

ulnar joint were performed in nine cases with the result that a rotational movement of more than one half of the normal range was obtained in six cases

The advantage of the J-K membrane is that apparently it produces less adhesions in the newly established joint compared with the other kinds of interposition (Putti 1920, McAusland 1921, Nagayama et al 1971), and also it permits a minimal amount of bone resection

In our opinion this classical arthroplasty of the elbow is well worth trying because it results in a stable joint with a useful range of mobility and freedom from pain Endoprosthesis should be reserved for the rare cases with pronounced bone destruction and very unstable joints

It can be concluded that arthroplasty of the elbow using J K membrane, properly performed in selected cases, offers a useful range of motion with good stability and strength It is indicated for patients between 15 and 60 years of age, when functional disability is the result of rheumatoid arthritis and fracture or fracture dislocation of the elbow joint

ACKNOWLEDGMENTS

The author wishes to express his gratitude to Professor Atsuto Nishio and Assistant Professor Akira Kobayashi for their support and helpful suggestions

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(Figure 3) It was not possible to deduce the exact thickness of the articular cartilage No dispersion of the air to the radioulnar joint was seen

The roentgenographic changes following arthroplasty do not parallel the functional result However the irregularity of the joint surfaces the hypertrophic changes and incongruity of the joint do not cause pain In fact no patient in this series has suffered from pain in carrying out daily activities

Ulnar nerve palsy and other neurological disturbances were not found



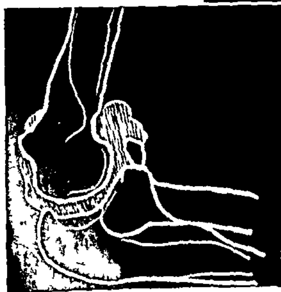


Figure 3 Air arthrography of Case 6

DISCUSSION

It appears from our series of patients that the mobility of the elbow remains unchanged in spite of gross roentgenographic changes However cases with an infectious origin lead to very poor functional results If this procedure is selected the surgeon should be certain that the inflammatory process has completely subsided In general it may be stated that previous infection is a contraindication, even though the means available for antibiotic treatment are far better today than they were 30 years ago (Campbell 1922 1924 Phemister & Miller 1924)

It seems that muscle weakness due to long term loss of mobility is not always irreversible if adequate and sustained muscle training is instituted before and after operation

The best indication for the arthroplasty is functional disability due to rheumatoid arthritis because in these cases the anatomical shape of the condyle is often preserved If, on the other hand excessive bone atrophy is present the procedure is contraindicated

The amount of bone resection should be determined with the aim of obtaining a balance between good mobility and preservation of a stable joint The range of motion in this series was not always satisfactory because of a reluctance to remove too much of the end of the humerus when compared with the procedures of Hass (1944) D Aubigné & Kerboul (1966) and Hurri et al (1964) This may explain why serious instability due to excessive condylar resorption was not found We do agree with Knight & van Zandt (1952) who recommended a gap after bone resection of three quarters of an inch Excessive resection of the radial head should also be avoided In our series reshaping instead of resection of the radial head and interposition of the J K membrane in the proximal radio-

ulnar joint were performed in nine cases with the result that a rotational movement of more than one half of the normal range was obtained in six cases

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(Figure 3). It was not possible to deduce the exact thickness of the articular cartilage. No dispersion of the air to the radioulnar joint was seen.

The roentgenographic changes following arthroplasty do not parallel the functional result. However, the irregularity of the joint surfaces, the hypertrophic changes and incongruity of the joint do not cause pain. In fact, no patient in this series has suffered from pain in carrying out daily activities.

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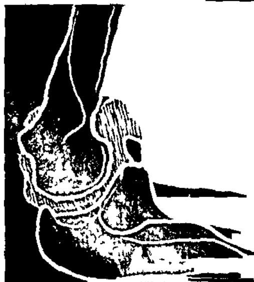


Figure 3 Air arthrography of Case 26

DISCUSSION

It appears from our series of patien that the mobility of the elbow remai unchanged in spite of gross roentge ographic changes. However, cases wi an infectious origin lead to very po functional results. If this procedure selected, the surgeon should be certa that the inflammatory process has co pletely subsided. In general it may l stated that previous infection is a co traindication, even though the mea available for antibiotic treatment are f better today than they were 30 years a (Campbell 1922, 1924, Phemister & Mil 1924).

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The amount of bone resection should be determined with the aim of obtaining a balance between good mobility and preservation of a stable joint. The range of motion in this series was not always satisfactory because of a reluctance to remove too much of the end of the humerus, when compared with the procedures of Hass (1944), D'Aubigné & Kerboul (1966) and Hurri et al (1964) This may explain why serious instability due to excessive condylar resorption was not found We do agree with Knight & van Zandt (1952) who recommended a gap after bone resection of three-quarters of an inch Excessive resection of the radial head should also be avoided In our series, reshaping instead of resection of the radial head and interposition of the J-K membrane in the proximal radio-



Figure 2 A Hypertrophic pseudarthrosis



Figure 2 B Operation performed

is applied postoperatively for a couple of weeks, and passive mobilisation exercises of the shoulder joint are started immediately All the patients were re examined from 10 to 23 months after the operation

RESULTS AND DISCUSSION

During the follow up period, the cases operated were examined both clinically and radiologically, and complete healing was demonstrated in all patients A typical pseudarthrosis before and after treatment is shown in Figure 2 The treatment described above for clavicular pseudarthrosis has yielded excellent results, has proved to be simple to perform, and has been without any complications

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TREATMENT OF POSTTRAUMATIC CLAVICULAR PSEUDARTHROSIS

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Six patients with posttraumatic pseudarthrosis of the clavicle were treated during 1973 and 1974 with an operative technique consisting of trimming of the bone ends, placement of a cortical bone transplant posteriorly and a metal plate anteriorly, and fixation of the plates with screws At examination 10 23 months postoperatively complete healing had been achieved in all cases

Key words clavicle fractures, pseudarthrosis surgery

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Development of a pseudarthrosis after clavicular fracture is uncommon regardless of treatment, but it seems to occur more frequently after primary operative than after conservative treatment (*Watson-Jones 1960, Apley 1968*) *Neer (1960)* reports the incidence of pseudarthrosis after clavicular fracture to be 0 1 per cent after conservative treatment, and 4 4 per cent after operative treatment in a material of 2235 conservatively treated and 45 operated patients *Rowe (1968)* reports the incidence as 0 8 and 3 7 per cent, respectively

PATIENTS AND METHODS

During the years 1973 and 1974 six patients with posttraumatic clavicular pseudarthrosis presented for treatment *Half of the patients* were younger than 20 years on admission the oldest one being 57 years five were males and one was a female Three had a right sided and three a left sided fracture The time interval between fracture and pseudarthrosis operation varied between 6 months and 3 years The reason for the long interval in some cases was lack of trouble some symptoms as also pointed out by *Campbell* (1971) and Salellarides (1961)

The operative technique applied was introduced by the late Professor Alvik (*personal communication 1965*) The bone ends are trimmed a cortical bone transplant is modelled in the form of a plate and placed on the supero posterior aspect of the clavicle and a 4-6 hole metal plate is placed on the infero anterior aspect The medullary side of the transplant faces the clavicular cortex after roughing of the latter with a chisel Screws from the metal plate fasten both plates to the clavicle and secure a rigid fixation A schematic presentation of the technique is given in Figure 1

The choice of bone for transplantation was determined by the demand for strength and the availability of bone In three cases a homotransplant of tibia sponge from the bone bank was used while in the remaining cases autotransplants from the tibial crest were used Mitella



Figure 1 Principle of fixation Screws from the metal plate pass through the clavicle and the bone transplant



F gure 2 A Hypertr phic pseu larthrosis



I gure 2 B Operation perf rme l

is appl ed postoperatively for a couple of weeks and passive mobilisation exercises of the shoul der joint are started immediately All the pa t ents were re examined from 10 to 23 months after the operation

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SPINAL NERVE BLOCK

A Diagnostic Test in Sciatica

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The cause of sciatica has been studied by blocking spinal nerves of the lumbosacral plexus in intervertebral foramina The nerve, which is singled out with the aid of an image intensifier, is injected with 1 ml of 1 per cent Xylocain If the Xylocain injection eliminates the sciatic pain, the surgeon may be confident that a true nerve root compression is involved, and he can then explore as far as he finds necessary The correlation between the site of compression and the level indicated by the test was confirmed by operation in 19 patients

Key words anaesthesia, local, sciatica, diagnosis, aetiology, intervertebral disc displacement, diagnosis

Accepted 14 x 76

Surgery has been a valuable method of treating sciatica since Mixter & Barr (1934) demonstrated the role that the rupture of an intervertebral disc plays in its aetiology In order to plan the operation correctly, it is essential to determine the particular nerve root from which the patient's symptoms arise Neurological signs have proved to be somewhat inaccurate for assessment of the level of disc herniation (Troupp & Ulfves 1959, Knutsson 1961) Myelography appears to be a more reliable means for the determination of the vertebral level (Karaharju et al 1974) However, a false negative result of myelography is a possibility and in cases of previous laminectomy the interpretation of positive findings may be difficult Consequently, some other method of examination would be of value

Injection of local anaesthetic has been recommended as a useful test in this respect (Macnab 1971, Schultz et al 1973, Krempen & Smith 1974) An essential part of this technique has been to inject contrast medium into the root sleeve in order to confirm the proper positioning of the needle This is followed by the injection of a local anaesthetic, which will eliminate sciatic pain if the cause of pain is to be found somewhere along the course of this particular nerve root We have carried out this test without contrast medium

PATIENTS AND METHODS

The patient lies in the prone position with a cushion under the lower abdomen to bring the sacrum as close to the horizontal level as possible With the aid of an image intensifier a lumbar puncture needle is inserted towards the lateral part of the intervertebral foramen and moved cautiously until the patient experiences a sharp stab of sciatic pain If the first sacral

Table 1 Myelographic and operative findings in patients in whom the level of spinal nerve compression was localized by a positive nerve block test

Spinal nerve compressed	Disc prolapse + Myelogram +	Disc prolapse + Myelogram —	Disc prolapse — Myelogram —	*Total*
L III	–	–	1	1
L IV	–	–	–	–
L V	4	–	7	11
S I	1	2	4	7
	5	2	12	19

nerve is to be tested the needle must be inserted into the first sacral foramen In this way it will be possible to ascertain which of the spinal nerves produces the patient s typical pain Following this 1 ml of 1 per cent Xylocain is then injected into this nerve Relief of symptoms will follow in a few minutes Should a previously positive Lasegue test become negative care must be taken in testing straight leg raising because there is a risk that the anaesthetized nerve root may be overstretched (Langenskiöld 1975)

This test has to date been used on 22 patients In 19 of them 11 men and 8 women mean age 43 years, operation confirmed that a positive test had identified the actual nerve subject to compression (Table 1)

The cause of compression was a herniated disc in seven patients In five of these the injection test correlated with a positive myelogram the prolapse being found at the L IV V level in four patients and at the lumbosacral level in one In two patients with a negative myelogram a herniation was found to be compressing the nerve root which the nerve block had identified as being affected The intervertebral space was L V S I in both cases

In 12 patients with a negative myelogram no herniated disc was found at operation but the level of compression had been correctly identified by the nerve block The cause of compression was traced back to a bony entrapment of the intervertebral forame[illegible]

str[illegible]

roo[illegible]

in [illegible]

tien[illegible] the root involved was L III in seven it was L V and in four S I Three patients had previously been operated on for a herniated disc It is worth mentioning that outside this series a false positive test was obtained in one patient in whom 5 ml instead of 1 ml Xylocain had been injected into the L V nerve at the presacral level The symptoms were caused by a herniated disc compressing the S I root

DISCUSSION AND CONCLUSIONS

It has been recommended that the correct position of the needle should be first confirmed by an injection of contrast medium (Macnab 1971, Krempen & Smith 1974) If the needle is not in the root sleeve, the sinuvertebral nerve may be anaesthetized resulting in an incorrect evaluation of the sciatic problem (Krempen & Smith 1974) When the needle is inserted in the manner described above, it is intended to enter the spinal nerve beyond the dural sheath Owing to the anatomy of this region (Pedersen et al 1956), it is possible that both the sinuvertebral nerve, which passes through the intervertebral foramen, and the posterior ramus of the spinal nerve will be anaesthetized However, this need not lead to a mistaken judgement, since the sinuvertebral nerve supplies the ventral dura and the posterior longitudinal ligament and according to observations made during disc operations, under local anaesthesia pain originating in these structures has solely a lumbosacral and not a sciatic character (Wiberg 1950) Such an injection may also suppress the pain that originates in the area of the first posterior branch of the spinal nerve Although this kind of pain may radiate to the lower extremity, it should be distinguishable, by the absence of neurological signs, from radiating pain due to nerve-root compression (Steindler & Luck 1938, Sinclair et al 1948) To pre-

vent anaesthesia from spreading into the spinal canal, only 1 ml Xylocain should be injected

Our experience has shown that spinal nerve block in the lumbosacral region is a valuable test even without the information obtainable by contrast-medium injection The techniques involved no complications or difficulties We recommend this test for use whenever the level of nerve root compression is uncertain, particularly when the myelogram is negative or difficult to interpret and compression at foraminal level is suspected

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INFANTILE AND ADOLESCENT IDIOPATHIC SCOLIOSIS IN THE SAME INDIVIDUAL

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Sophies Minde Orthopaedic Hospital University of Oslo, Norway

A patient with an infantile, resolving type of idiopathic scoliosis is presented By the age of 10 years, 4 years after complete spontaneous correction, the girl had developed a structural, progressive idiopathic scoliosis to the opposite side

Key words scoliosis infantile adolescent, idiopathic

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There are great differences between the infantile and the adolescent type of idiopathic scoliosis In the early onset group boys predominate, the curve is usually to the left, and in most cases the scoliosis resolves (James et al 1959, Lloyd-Roberts & Pilcher 1965) A great geographical variation in incidence is found, and there are strong indications that environmental factors are acting in this type of scoliosis (Wynne-Davies 1968, 1975, James 1973) In the adolescent group five out of six cases are females, the curve is usually to the right, and it tends to progress during the entire growth period

However, the infantile and adolescent types of idiopathic scoliosis are often found in the same family, and therefore, in spite of the differences, Wynne-Davies (1968 1973) held the opinion that both share the same basic etiology

Lloyd Roberts & Pilcher (1965) stated that no fully resolved curve ever deteriorates The purpose of the present paper is to present a patient with an infantile idiopathic scoliosis which resolved and who later on developed a curve to the opposite side We have not come across any similar case in the medical literature

CASE REPORT

The patient is a girl born 16 September 1959 Pregnancy and delivery were normal *A few* months after birth the parents noticed a deformity of her spine The girl was seen at our hospital for the first time when 1 year old She *presented with a left* sided thoracic scoliosis and a rib hump on the same side X ray showed a thoracic curve measuring 32° *extending from* T8 to L1 with distinct rotation and apex at T10–11 Compensatory curves were present above and below, and the difference in rib angle was 17° (Figure 1 a) Examination revealed no [illegible]

followed up at half yearly intervals At the age of 2 years and 6 months the curve was 33° (Figure 1 b) One year later it had decreased spontaneously to 20° (Figure 1 c), but still the patient presented with an *obvious rib* hump The curve improved further, at 4 years and 6 months it measured 12° (Figure 1 d), and at 6 the spine was straight

The patient was still followed up at regular intervals At 10 a slight curvature to the right side was found, and when 12 years old she presented with an obvious structural scoliosis

vent anaesthesia from spreading into the spinal canal, only 1 ml Xylocain should be injected

Our experience has shown that spinal nerve block in the lumbosacral region is a valuable test even without the information obtainable by contrast-medium injection The techniques involved no complications or difficulties We recommend this test for use whenever the level of nerve root compression is uncertain, particularly when the myelogram is negative or difficult to interpret and compression at foraminal level is suspected

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is not demonstrable in this case and there is no indication of environmental factors

In Norway we have a rather low incidence of infantile idiopathic scoliosis compared with the figures from Great Britain given by Wynne-Davies (1968), Riseborough & Wynne Davies (1973) and James (1975) In the past few years we have treated only one or two cases per year at Sophies Minde Orthopaedic Hospital, where most cases of scoliosis from all over Norway have been treated up till now For comparison, at the same hospital, we treat about 100 new cases of juvenile and adolescent idiopathic scoliosis yearly

If, as stated, all types of idiopathic

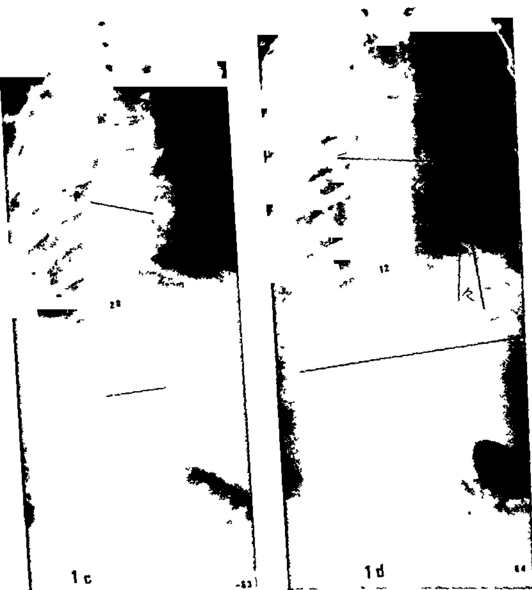


Figure 1 Left-sided resolving type of infantile idiopathic scoliosis in a girl, at 1 year (a) at 2 years (b) at 3 years (c) and at 4 years (d) of age

with convexity to the right side, measuring 18° and extending from T 6 to L 2 with apex at T 11-12 (Figure 2 a) One year later the curve had increased to 24° (Figure 2 b) and treatment with a Milwaukee brace was started She matured at sixteen, her height was then 164 cm, and the curve 28° (Figure 2 c)

DISCUSSION

The first episode of spinal deformity of the case presented was typical for an infantile idiopathic scoliosis of the resolving type The second curve, occurring about the age of 10, 4 years after complete recovery of the first, is a typical adolescent idiopathic scoliosis Heredity



is not demonstrable in this case and there is no indication of environmental factors

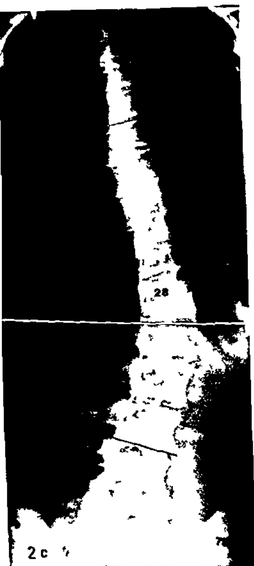
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Figure 2. X-rays of the same girl as in Figure 1, at 12 years (a), at 13 years (b) and at 16 years (c) of age. She has now developed a right-sided progressive type of idiopathic scoliosis.

scoliosis have the same underlying genetic influence it is really not surprising that we may see early and late onset scoliosis in the same individual. The environmental triggering factors supposed to act in adolescence may also affect patients who at an early age have had a resolving type of infantile scoliosis. In countries where this type of scoliosis is frequent, one might perhaps expect more cases like the one presented here, if infantile and adolescent idiopathic scoliosis share the same basic etiology.



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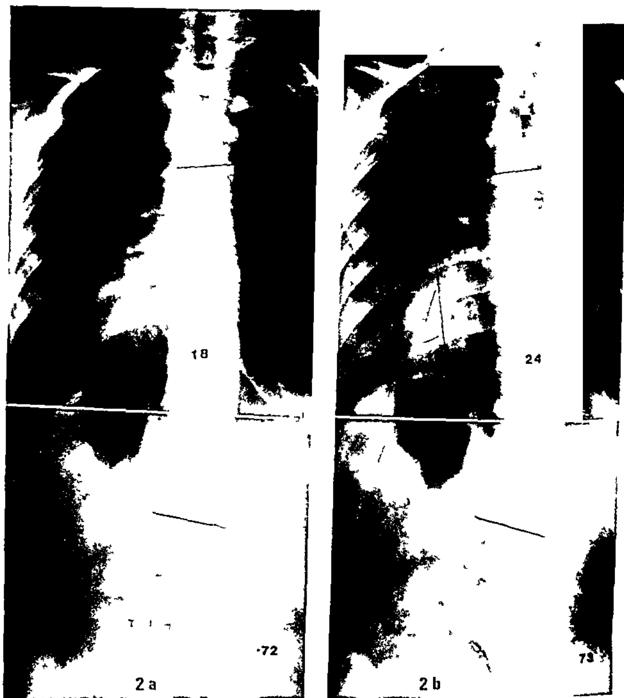


Figure 2 X-rays of the same girl as in Figure 1, at 12 years (a) at 13 years (b) and at 16 years (c) of age She has now developed a right sided progressive type of idiopathic scoliosis

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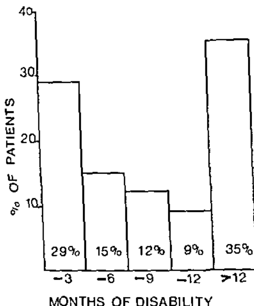


Figure 1 Distribution of 116 patients according to the total duration of postoperative disability

clinical X ray and operative findings. 2) From the Health Insurance Office files all periods of sick leave for low back disorders between 1955 and April 1976 3) From the questionnaire completed at the patient s interview the evaluation of the whole postoperative course especially in terms of residual symptoms and working capacity

Some patients did not go to work at all after the operation and the total period of disability the sum of all postoperative sick leave periods) was in these cases regarded as infinite The presence of patients with an infinite disability [illegible] of disability as a basis for comparison between the groups Instead the method of normal probability graphs (Amador & Hsi 1969) was used separating the whole patient popula[illegible] tion [illegible] cha[illegible] postoperative disability included 75 patients 65 per cent of the total population) The limits of the "normal length of total postoperative disability ranged up to 1 year In 41 patients (35 per cent of the population) this period of disability was longer than 1 year These patients constituted the other group classified throughout this paper under the heading "extended total duration of disability

A number of factors were tested against these two groups of patients The comparison has been made as an item analysis with the different variables examined separately The chi square test was used as a test of independence between two categories of classification The indications for the surgical treatment and the surgical technique were standard As regards the length of the sick leave period only the time period during which the patient s working capacity was diminished, according to the Swedish Health Insurance Office files, was considered The degree of incapacity (whole or one half incapacity) was disregarded Sick leave spells shorter than 8 days were also included, despite the fact that medical certificates are not compulsory for such periods Only diagnoses for low back disorders were considered

RESULTS

The course of events as regards sick leave for low back troubles

In the group of 116 patients the total number of days spent on sick-leave for low back disorders was followed for 10 years before and 10 years after surgery (Figure 2) It is apparent that the number of days on sick leave increases continually during the whole investigation period and that this is unaffected by surgical treatment The same trend was also observed when only the number of sick leave periods were investigated On the other hand, the number of patients with severe recidivous sciatica necessitating hospitalization showed a decreasing trend, being 6 per cent of the whole patient population in the first postoperative year and diminishing subsequently to a constant level of 1 per cent of the whole patient population from the fifth postoperative year

Preoperative factors influencing total duration of disability (TD)

a) General characteristics of the patient The age and sex were without influence on the TDD The patients with the "extended' TDD had more often other serious diseases in their past his-

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DURATION OF DISABILITY FOLLOWING LUMBAR DISC SURGERY

VALDEMAR V SURIN

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The total duration of disability of 116 patients operated on for lumbar disc prolapse was studied 10 years postoperatively From the beginning of the observation period 10 years before surgery, the number of days on sick-leave increased continually and no positive effect of the surgical treatment in this respect could be observed There was a highly significant coincidence between the end result assessment by the patient and the total duration of the postoperative disability The following factors were conducive to a short total period of post operative disability early surgery (short interval of preoperative sciatica), short total preoperative period of sick leave and immediate relief of sciatic pain by the operation The objective changes in the preoperative state of the patient such as neurological and X ray findings had a less significant influence

Key words lumbar spine, disc prolapse, surgery, disability

Accepted 7 iii 77

The goal of lumbar disc surgery is to relieve pain and disability From this viewpoint, the long-term course of events as regards sick-leave following surgery is important Whereas the factors connected with sick-leave in non-operated patients with low back disorders has been the subject of earlier investigations (Westrin 1973), the rare reports on sick-leave in patients operated on for lumbar disc prolapse are based on selected patient populations (Hakelius 1970) To the author's knowledge there are no earlier investigations dealing with the course of events as regards sick-leave in unselected patients operated on for lumbar disc prolapse

PATIENTS AND METHODS

All patients operated on for suspected lumbar disc herniation during 1964 and 1965 were included in this retrospective study, thus ensuring an equal follow up interval in all investigated patients

A total of 140 patients were operated on and of this number 129 (92 per cent) could be assessed This study was made during the year 1976 and the follow up period thus ranged between 10 and 11 years Thirteen patients who retired during the follow up time were excluded from this part of the investigation, leaving 116 patients The mean age of the patients at operation was 41 8 years and the ratio men women was 2 1 The composition of our patient population in this respect compares with previous reports (Spangfort 1972)

The following data were evaluated for each patient 1) *From the medical case record* the patient's biographic data the preoperative and postoperative course of low back disorders, the

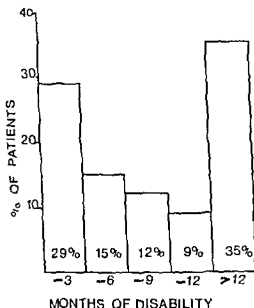


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Some patients did not go to work at all after the operation and the total period of disability the sum of all postoperative sick leave periods) was in these cases regarded as infinite The presence of patients with an infinite disability time and the fact that the total duration of disability was found to form a skewed distribution (Figure 1) invalidated the use of average duration of disability as a basis for comparison between the groups Instead the method of normal probability graphs (Amador & Hsi 1969) was used separating the whole patient population into two groups according to the total duration of postoperative disability The one group characterized by a normal total duration of postoperative disability included 75 patients 65 per cent of the total population) The limits of the "normal length of total postoperative disability ranged up to 1 year In 41 patients (35 per cent of the population) this period of disability was longer than 1 year These patients constituted the other group classified throughout this paper under the heading "extended" total duration of disability

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Preoperative factors influencing total duration of disability (TD)

a) General characteristics of the patient The age and sex were without influence on the TDD The patients with the extended TDD had more often other serious diseases in their past his

Table 1 General characteristics of 116 patients related to the total duration of disability (TDD)

Factor	Per cent of patients in the group "Normal" TDD	"Extended" TDD	Significance
Other diseases	24	43	$P < 0.05$
Heavy work	42	66	$P < 0.05$
Mean sum of preoperative sick-leave days	143	232	$P < 0.001$

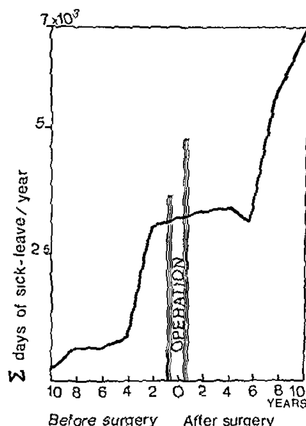


Figure 2 The sum of sick-leave days per year in all 116 patients Variations during the 10 years before and the 10 years after surgery Staples sick leave days immediately before and after surgery

tory, did heavier work preoperatively and were more often and for a longer time on sick-leave for low back disorders during the 10 years prior to surgery (Table 1)

b) The duration of preoperative symptoms We tried to differentiate between the past history of low back troubles and the duration of the sciatica bout immediately preceding surgery By 'past history" we mean the duration of symptoms from the first onset as opposed to the defined period preoperatively during which the appearance or deterioration of sciatica developed, in spite of conservative treatment, until surgery was performed All these estimations are based on autoanamnestic data

The "long-term history" of low back troubles before operation was sometimes diffuse and any average duration of these troubles was therefore impossible to estimate Instead the number of patients claiming not to have had previous low back disorders before operation (with the exception of the sciatica bout immediately preceding surgery) were estimated in both groups It appeared that there were 30 per cent of these patients in the "normal" and 37 per cent in the "extended TDD group, the difference being not significant To assess the recall ability of these patients as regards low back disorders, the number of sick-leave spells for a diagnosis of low back disorder during the 10 preoperative years were studied It appeared that out of 36 patients, 29 (80 per cent) had no such sick-leave spell, five had only one such spell shorter than 2 weeks and only two patients had repeated sick-leave periods totalling 230 days

The duration of the sciatica bout immediately preceding surgery was stated very precisely by the patients The mean duration of this sciatica period was 130 days in patients with "normal" and 300 days in patients with "extended" TDD, the difference here being highly significant ($P < 0.001$) Closer analysis revealed (Figure 3), that the TDD was directly proportional to the duration of

Table 2 Operative findings in 116 patients related to the total duration of disability (TDD)

Factor	Per cent of patients in the group "Normal TDD	Extended TDD	Significance
Complete disc prolapse	40	21	$P < 0.05$
Coincidence of estimated level of nerve root impairment and that found at operation	95	78	$P < 0.01$
Immediate relief of pain after surgery	52	17	$P < 0.001$

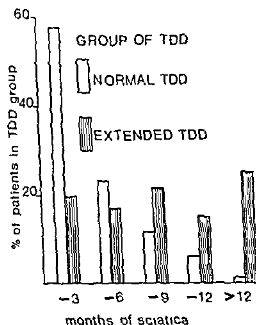


Figure 3 Distribution of the patient groups with normal and extended postoperative duration of disability according to the duration of preoperative sciatica.

immediate preoperative sciatica It is also interesting to note that the patients operated early (duration of sciatica shorter than 3 months) have the best results when other evaluation *criteria* (subjective assessment) are considered

c) The preoperative state and the X ray findings In the group with "normal TDD 75 per cent of the patients had Lasègue sign at 45° as compared with 41 per cent in the group with "extended TDD, the difference is significant ($P < 0.01$) The severity of nerve root impairment, the level and the side (right or left) of the prolapse were without prognostic significance The presence and the degree of spondylosis and spondyl arthrosis on preoperative X rays of the lumbar spine were also without predictive value Sixty one per cent of the total patient population were myelographied The myelographic pattern of dura indentation was present in 65 per cent of the myelographies of patients with normal and in only 36 per cent of the myelographies of patients with extended TDD, the difference is significant ($P < 0.05$)

d) The operative findings The coincidence of the level of nerve root impairment, as estimated preoperatively, with the level found at surgery, the presence of complete disc prolapse and the immediate relief of sciatic pain after surgery are all important prognostic factors (Table 2)

The TDD correlated with the patient s estimation of the end result

The patients assessment of the operative result 10 years after surgery coincides very well with the total duration of postoperative disability (Table 3), as was expected But it is important to note in this regard that this coincidence was valid in our patient population only for the sum of all sick leave periods over the 10 years of postoperative follow up, while

the length of the solitary sick-leave spell, following immediately after surgery was without connection with the end-result

Table 3 End results in 116 patients related to total duration of disability (TDD)

End result assessment	Per cent of patients in the group	
	"Normal" TDD	"Extended" TDD
Completely satisfied	36	10
Improved but minor complaints		
backache	39	17
leg pain	17	27
Dissatisfied	8	46
Total	100	100

DISCUSSION AND CONCLUSIONS

With a view to studying the differences in the course of events as regards disability time over a long period, the idea of "normal" and "extended" duration of disability following surgery was developed The basic idea to separate a sample of sick individuals into two groups, the one classified as following a "normal", the other a "delayed" (in this case "extended") course of healing, is well known from the statistics of fracture healing There is no apparent reason why this concept should not to be used to characterize the course of events as regards disability time following surgery for lumbar disc prolapse The only problem in this respect is to define the range of normality The simplest of indirect methods for estimation of normal range, using normal probability graphs, appeared to be fully appropriate to our study

The reliability of a diagnosis of low back disorder collected from the Health Insurance Office files can be discussed with respect to the possibility that this covers other causes of work absence Most authors (Beals & Hickman 1972, Westrin 1973), however, consider it improbable that sick-leave because of low back disorder covers pure malingering The high degree of correlation between the total duration of postoperative sick leave and the patient's own assessment of the end results reflects the fact that the patient himself controls the duration of disability

The duration of preoperative symptoms as a prognostic factor in patients operated for lumbar disc prolapse is seldom mentioned and the statements in the published reports are very controversial Hakelius (1970) found more favourable results in patients with less than 2 months duration of sciatica, Karaharju et al (1974) noted less favourable results in these patients and Hirsch & Nachemson (1963) concluded that the end-results are not influenced by early (< 2 months) or late (> 6 months) surgery According to Karaharju et al (1974) there is no correlation between the duration of preoperative sciatica and late symptoms, Roslund (1974) found that preoperative sciatica of more than 8 months duration is a bad prognostic factor and Jackson (1971) noted that the incidence of late low back pain is directly related to the duration of preoperative symptoms Our own experience from this study confirms the favourable prognosis of patients operated early If the patient has symptoms and signs enough to warrant surgery, then he should be operated on without due respect to the short duration of sciatic symptoms

The patients in our study who had protracted total duration of disability following surgery also had some traits in common in their preoperative history They were more often sick in general, more often on sick-leave for low back troubles, and were usually doing heavy jobs Their signs and symptoms of sciatica are not severe enough and consequently surgery is delayed

When one considers why surgery fails in these patients, it must be remembered that a given patient's response to pain is very much a psychological phenomenon Beals & Hickman (1972) found a close relationship between the psychological pattern of a patient with low back injury and the time which had elapsed since injury As the time following the injury increases the patients tend to exaggerate their physical symptoms Wiltse & Rocchio (1975) studying patients treated with chemonucleosis came to the same conclusion From previously published papers and also from our own study it is not clear if these patients have had these psychological distress symptoms to begin with or if there is some cause and effect relationship provoked by the fact that the surgery was performed too late Radiating leg pain is a symptom not a disease and the causes of the symptom may lie outside the spinal nerve root, which seems to be the case when the symptoms last for a long time

From our study it appears that the evolution of sick leave for low back troubles during the preoperative period can be one of the evaluating instruments when surgical treatment in these patients is considered At the same time the total duration of postoperative disability is one of the important criteria when the end results of lumbar disc surgery are assessed

The results of this study also bear out the following If the patient has protracted leg pain symptoms but minimal objective findings one should be very slow to resort to surgical treatment Every effort should be made to assess in these patients the role that emotional responses or functional overtones play in the disability presented There is no place for explorative lumbar surgery in these patients

ACKNOWLEDGEMENT

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SPONDYLOLISTHESIS

Treatment by Excision of the Loose Lamina and Resection of the Pedicle

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Eighty patients were treated by radical arch resection i e, removal of the loose lamina and the fibrous tissue in and around the pseudarthrosis and resection of the caudal portion of the ventral part of the pedicle In 17 patients an additional spinal fusion was performed The mean observation time was 4 7 years The forward dislocation increased by 25 per cent in the group without fusion compared with 16 per cent in the fused group The symptoms of nerve root affection for the most part improved, but the back pain persisted in 28 patients Fifty per cent of the patients were in full time employment at the time of the follow up A total of 75 per cent were improved and 25 per cent unchanged or worse

Key words lamina excision, pedicle resection, spondylolisthesis

Accepted 2 xii 77

The treatment of spondylolisthesis in our department, for more than 15 years, has been surgical procedures for younger patients while a more conservative approach has been the rule with older patients During the period 1955–1970, 220 operations were performed, 80 laminectomies and 140 spinal fusions

Studying the results of the early operations, we learned that simple laminectomy was not sufficient and that the Gill procedure (Gill et al 1955), in our hands, failed to provide relief in several cases Alvik (1969) found, in a high percentage of cases, a special mechanism causing nerve root impingement in spondylolisthesis The root proximal to the dislocated segment was found to be compressed to a greater or lesser extent between the pedicle of the spondylolisthetic arch and the posterior part of the underlying corpus and disc (Figure 1)

As a consequence of this we have altered the surgical procedure The purpose of this paper is to study the results of this revised surgical method Laminectomy combined with resection of the pedicle, in our department called "radical arch resection"

METHOD

Radical arch resection consists of removal of the loose lamina and the fibrous tissue in and around the pseudarthrosis and in addition resection of the caudal portion of the ventral part of the pedicle (Figure 1) The patients are allowed to get out of bed 1–2 days after the operation without a corset Active exercises are started at once

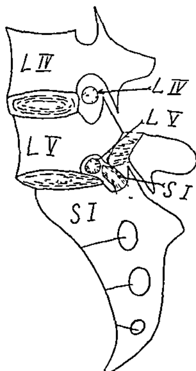


Figure 1 The part of the pedicle to be resected marked with the dotted line The fifth lumbar root is compressed between the pedicle and the underlying bone and the disc

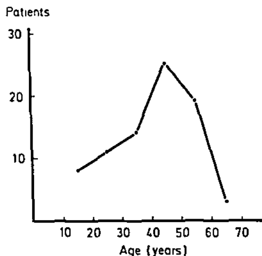


Figure 2 Age distribution

PATIENTS

A series of 80 patients have been treated with this operation during the period 1955–1970, there were 43 males and 37 females aged 12–68 years The mean age was 39 6 years The age distribution is shown in Figure 2 The observation time was 2–18 years with an average of 4 7 years In 17 patients some form of spinal fusion was carried out in addition to the arch resection 16 had posterior (intercorporal intertransversal or dorsal) and one anterior fusion The fused patients were immobilised—mostly in a plaster cast—for 4 months

In Figure 3 the anterior dislocation is graded according to Meyerding (1932) Most of the cases belonged to grades I and II (Table 1) Standard X rays were supplemented by oblique projections in order to get an exact impression of the pseudarthrosis which was present in all cases The spondylolisthesis was located to L_5–S_1 in 52 cases L_4–L_5 in 23 cases L_6–S_1 in three cases, L_3–L_4 in one and to both L_4–L_5 and L_5–S_1 in one case Spina bifida was found at the level of the fifth lumbar vertebra in three patients, at the first sacral in five and at both the first and second sacral vertebrae in one patient. The amount of anterior dislocation of the vertebral body was recorded as a percentage of the antero-posterior diameter of the inferior surface of the displaced segment The average slipping was 10 8 mm (24 6 per cent) ranging from zero to

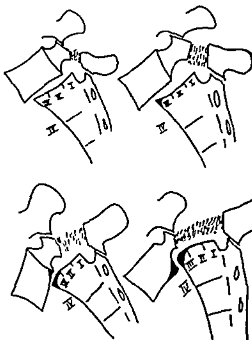


Figure 3 Grading of spondylolisthesis according to Meyerding

Acta orthop scand 48, 472–478, 1977

SPONDYLOLISTHESIS

Treatment by Excision of the Loose Lamina and Resection of the Pedicle

EINAR VESTAD & BJØRN NÆS

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A B

Figure 5 Grade 3 4 spondylolisthesis a) Before operation b) After radical arch excision and later anterior fixation which did not unite

A B

Figure 6 Typical increase in slipping a) Before and b) after radical arch excision

had less backache than the other two groups Among the fused patients there were 10 without increased postoperative slipping four with moderate and three with a marked increase (4 12 *mm*) The last three have persistent pseudarthrosis

25 mm. In males the average slipping was 22.9 per cent and in females 28.4 per cent.

Table 1. Grading of anterior dislocation

	I	II	III	IV
Before operation	62	17	1	0
After operation	54	22	3	1

Radiculography was performed in 76 patients. Signs of nerve root affection were found in 65 cases (Figure 4). *In 55 of these the radiculographic and neurologic findings correlated well. A herniated disc was found in six cases and was* verified in five cases at operation. One additional prolapse, not demonstrated radiculographically, was found at operation.

Complications, reoperation and additional spinal fusions

In the group of 63 patients without fusion there were *no immediate postoperative complications.* Three patients, however, were reoperated and neurolysis performed because of persistent root symptoms. Only one improved. Another four patients had additional anterior transperitoneal fusion because of a considerable increase in anterior dislocation following the initial operation. One of these did not heal (Figure 5). In one case a third operation—neurolysis—was performed because of persistent radicular and back pain but no improvement resulted. This patient also developed a ventral hernia after the fusion operation. Additional fusion was done in another three patients because of persistent severe back pain: one intertransversal, one combined dorsal/intertransversal and one dorsal. The latter patient developed a deep wound infection with a fistula and had to be reoperated because of non union.

In the combined radical/fusion group of 17 patients two developed superficial infection. Non union occurred in two of the six intercorporal fixations. Intertransversal fusion was done in one of them. Of the three dorsal fixations, two did not heal and were reoperated twice. One of them has a persistent pseudarthrosis. One patient with anterior fusion initially was reoperated *and intertransversal fixation performed* because of persistent back pain.

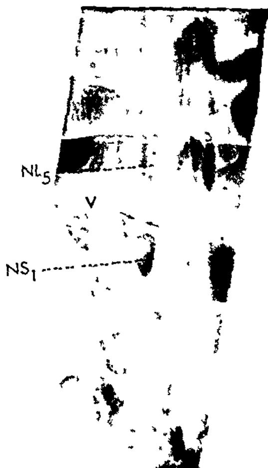


Figure 4. Radiculogram. The fifth lumbar root is disrupted at the pseudarthrosis level marked with arrows. Note increased interval between pedicle and root.

Table 2. Pre- and postoperative slipping for patients having radical arch excision without fusion

Age (years)	No of patients	Dislocation pre and postop (mm)	Dislocation increase (mm)	% increase
< 25	8	13.9–17	3.1	22.3
25–40	20	11.6–15.1	3.5	30.2
> 40	35	10 –12.1	2.1	21
Total	63	11 –13.7	2.7	25

RESULTS

Postoperative slipping. Following radical resection without fusion the anterior dislocation increased from 11 mm to 13.7 mm (Figure 6). The slipping was most marked in the middle age group (25–40 years) (Table 2). Surprisingly this group

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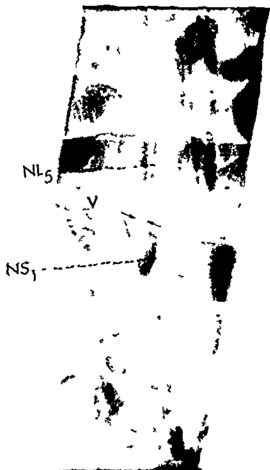


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Figure 7 Postoperative "rolling" The angle between the upper sacrum and the fourth vertebra has increased

In some cases "rolling" was observed on X-ray examination, i e an increased angle between the sacrum and the vertebra above the slipping vertebra (Figure 7)

Nerve root affection The signs of root affection were markedly improved The radicular pain, which was present in all cases before operation was improved in 63 (78 8 per cent) Objective signs present in 45 patients preoperatively were improved at follow up in 38 (Table 3)

Table 3 Nerve root symptoms before and after operation

		Radicular pains	Objective root signs
Before operation		80	45
After operation	No symptoms	45	30
	Improved	18	8
	Unchanged	12	6
	Worse	5	1

Local back pain In 49 patients (61 3 per cent) the back pain was considerably improved It was unchanged in 22 and worse in six patients Three patients had no pain before or after operation One patient without back pain before opera

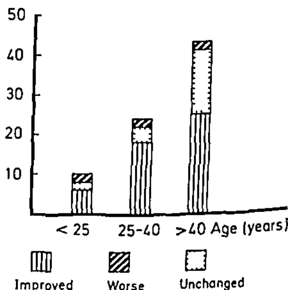


Figure 8 Back pain related to age See text

tion complained of pain at the follow up The middle age group seemed to be the most pain free (Figure 8)

Working capacity As shown in Table 4 the working capacity was greatly im proved The number of patients in em ployment was doubled after operation

Table 4 Working capacity

	Before oper at on	After oper at on
Incapable of work ng	46	20
Part al work ng capac ty	14	20
Full working capac ty	20	40

Overall end results were graded as fol lows

Excellent — No pain or mild occasional pain Able to carry out all activities

Fair — Improved with moderate pain in the back and/or ex trem ties Working capacity reduced to some degree

Poor — Persistent or increased pain in the back or lower extrem ities Incapable of working

As demonstrated in Table 5 half of the patients obtained a very satisfactory re sult 75 per cent were improved and 25 per cent are classified as failures With out fusion 30 per cent were failures

Table 5 Overall results

	Rad cal arch exc s on		Comb ned operation	
	No of pat ents	%	No of pat ents	%
Excellent	31	49	9	53
Fa r	13	21	7	41
Poor	19	30	1	6
Total	63	100	17	100

DISCUSSION AND CONCLUSION

Bosworth et al (1955) and Marmor & Bechtol (1961) thought that removal of the loose lamina might lead to instability with increasing anterior dislocation Gill et al (1955) did not share this opinion In agreement with Friberg (1939) Gill et al (1955) and Turner & Bianco (1971) we have not found any correlation be tween the grade of slipping and back pain

In addition to the radical arch excision we now invariably perform interverte bral fusion in patients below 50 Since 1969 we have used the intertransversal method which is simple and has proved for us to be the most reliable After radi cal arch excision the symptoms of nerve root affection as a rule disappear or im prove but the back pain often persists We believe that the backache is largely due to small movements in the dislocated segment Residual back pain after arch excision is therefore logically treated by secondary fusion

Compared with Gill s series our num ber of good results seems to be rather modest But they correspond well with the results of Cedell (1961) and Cedell & Wiberg (1970) who recorded distinct im provement in about 70 per cent of their series The evaluation of the results however is not always commensurable We believe that the present attitude to wards treatment of spondylolisthesis is not the final one It may be that the se lection of cases for surgical treatment should be more restrictive We feel that a few of the patients in the failure group would have been dissatisfied ir respective of treatment These patients are particularly liable to be victims of multisurgery

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THE SURGICAL TECHNIQUE FOR HINDQUARTER AMPUTATION

A Report of 19 Cases

KENT K WU, EDWIN R GUISE, HAROLD M FROST & C LESLIE MITCHELL

Department of Orthopedic Surgery, Henry Ford Hospital Detroit, Michigan, USA

The surgical technique for hindquarter amputation is described in a step by step manner Since 1955 we have performed 19 such operations for eradication of malignant bone and soft tissue tumors in the pelvic, hip and upper thigh regions Three hindquarter amputations were performed for local recurrence following initial wide excision The overall 5 year survival rate for our 19 patients was 42 1 per cent Malignant soft tissue tumors appear to have a much better 5-year survival rate than malignant bone tumors (60 per cent vs 22 2 per cent) We feel that surgery is still the treatment of choice However in the presence of proper indications chemotherapy and radiotherapy should be added to surgery in order to prolong survival time and save lives

Key words hindquarter amputation hemipelvectomy

Accepted 5 ix 77

Hindquarter amputation is synonymous with hemipelvectomy, disarticulation of the innominate bone, interilio-abdominal amputation, sacroiliac disarticulation, transiliac amputation, interpelviabdominal amputation and transpelvic amputation Its surgical technique was popularized by Gordon-Taylor and his associates (Gordon-Taylor & Wiles 1935, Gordon-Taylor 1940) and was subsequently modified by King & Steelquist (1943), Sorondo & Ferre (1948), and Banks & Coleman (1956) Due to the extremely mutilating nature of this operation, its primary usage is for eradication of malignant primary soft tissue and bone tumors of the pelvis hip and upper thigh regions (Gordon-Taylor & Wiles 1935, Gordon Taylor 1940, Pack & Ehrlich 1946, Pack et al 1947, Beck & Bickel 1948, Sugarbaker & Acherman 1949, Wise 1949, Lee & Alt 1953, Pack 1956, Bailey & Steven 1961, Pack & Miller 1964, Phelan et al 1964 and Marcove et al 1972)

In addition, occasionally, hindquarter amputation has been employed in the treatment of severe trauma (McPherson 1960, McLean 1962, Wade & Macksood 1965 and Johansson & Olerud 1971), metastases (Gordon-Taylor et al 1952, Bailey & Steven 1961 and Pack & Miller 1964), and infection (Alldred & Nisbet 1964)

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per approximately 17 000 operations or in terms of time one per year

The indications for our 19 hindquarter amputations are summarized in Table 1

Table 1

Disease	Number of patients
Malignant primary bone tumors	
Osteogenic sarcoma	4
Chondrosarcoma	4
Ewing s sarcoma	1
Malignant soft tissue tumors	
Rhabdomyosarcoma	4
Fibrosarcoma	3
Mesenchymoma	2
Extraosseous osteogenic sarcoma	1

There were 11 males and 8 females Sixteen of them were white and three black Their age distribution is shown in Table 2

Table 2

Decade	Number of patients
0 9	0
10–19	4
20–29	2
30 39	3
40 49	2
50–59	2
60–69	6

METHODS

Primary treatments in our 19 patients are listed in Table 3

Table 3

Primary treatment	Hindquarter amputation	Wide local resection	Radiotherapy plus hindquarter amputation
Number of patients	15	3	1

With the exception of the one case of Ewing s sarcoma radiotherapy and chemotherapy were reserved for recurrence of tumors and metastases Only one patient underwent pulmonary lobectomy for metastases and he died 1½ years postoperatively from widespread metastases No prophylactic chemotherapy was used in this series

SURGICAL TECHNIQUE

Prior to the amputation, insertion of a Foley catheter, suturing of the anus and administration of prophylactic intravenous antibiotic are routinely carried out *The patient is placed in a lateral position* and the affected leg is held in 45° of abduction

The amputation is performed in five steps

1 Step one, the skin incision (Figure 1), begins from the superior aspect of the sacroiliac joint, going along the iliac crest to the anterior superior iliac spine and then following the inguinal ligament to the pubic tubercle where the line becomes bifurcated one to the pubic

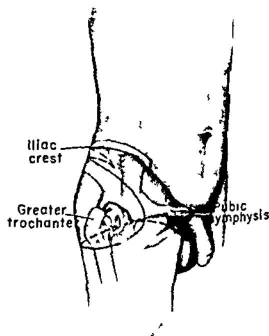


Figure 1 The skin incision

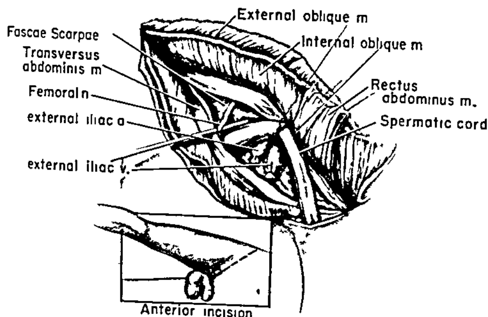


Figure 2 The anterior incision and resection

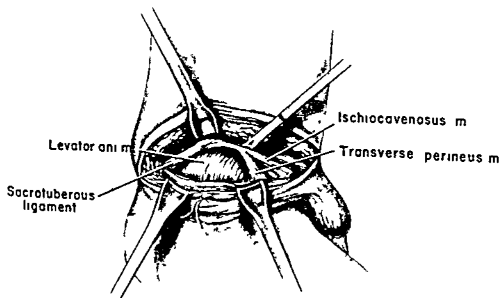


Figure 3 The perineal resection

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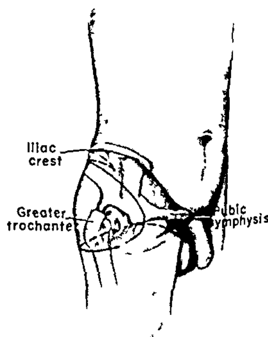


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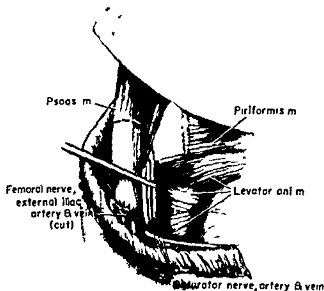


Figure 5 The intrapelvic resection

(Figures 4 and 5), is performed in the following order

a Detach the remaining abdominal muscles, the quadratus lumborum and the erector spinae muscles from the ilium

b Divide the gluteus maximus slightly above its insertion at linea aspera and retract the whole muscle together with its overlying skin and subcutaneous tissue as one flap upward and medialward

c Divide the piriformis muscle and the sciatic nerve

d Disarticulate the sacroiliac joint with a gigli saw

e Cut the sacrotuberous and sacrospinous ligaments

f Through the anterior incision, ligate and divide the obturator artery and vein

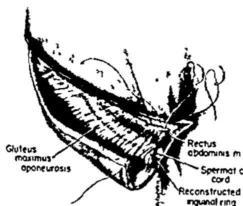
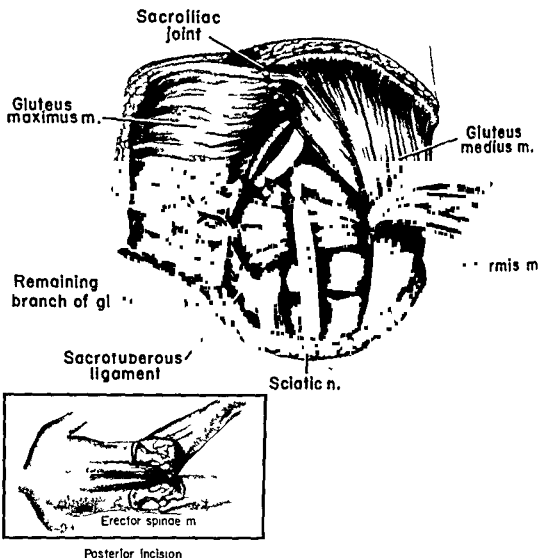


Figure 6 The reconstruction of inguinal ring and canal and skin closure



Posterior Incision

Figure 4 The posterior resection

symphysis, and the other along the perineal crease to the beginning of the gluteal fold The incision then travels the entire length of the gluteal fold to the greater trochanter from which the line is curved upward and medialward, slightly below the iliac crest, to the starting point

2 Step two, the anterior approach (Figure 2), is done in the following manner

a Detach the abdominal muscles, the inguinal ligament and the rectus abdominis muscle from their respective iliac and pubic attachments

b By retracting the spermatic cord and peritoneum upward and medialward ligate and divide the external iliac artery and vein and then cut the femoral nerve at the same level

c By retracting the bladder into the pelvis, the pubic symphysis is disarticulated by means of complete division of its ligaments and fibrocartilage

3 Step three, the perineal approach (Figure 3), is accomplished by detaching the ischiocavernosus, the transverse perineal and the origin of the upper levator ani muscles from the pubic bone in a subperiosteal manner

4 Step four, the posterior approach

Table 7

Author	Year	Number of patients	5 year survival rate (per cent)
Gordon Taylor & Munroe	1952	50	20
Higginbotham & Coley	1956	39	40
Lewis & Bickel	1957	50	50
Bailey & Steven	1961	16	25
Pack & Miller	1964	53	20 8
Marcove et al	1972	69	51

However in order to improve our patients long term survival rate, adjuvant chemotherapy is now routinely employed in treating certain malignant tumors, such as osteogenic sarcoma Ewing s sarcoma embryonal rhabdomyosarcoma etc Furthermore in addition to surgery radiotherapy and chemotherapy, we believe that immunotherapy will be added to our armamentarium when its effectiveness has been unequivocally proven

ACKNOWLEDGMENT

We wish to thank Mr Jay Knipstein for his superb drawings

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Table 4

Number of patients	Nature of disease	Site	Results
1	Chondrosarcoma	Proximal femur	All had local recurrence which required subsequent hindquarter amputation
1	Fibrosarcoma	Soft tissue of thigh	
1	Malignant mesenchymoma	Soft tissue of thigh	

Table 5

Duration	1 year		2 years		5 years and more	
	Dead	Living	Dead	Living	Dead	Living
Number of patients	5	14	9	10	11	8
Per cent	26 3	73 7	47 4	52 6	57 9	42 1

and cut the obturator nerve and the psoas muscle

g Completely detach the levator ani muscle from the pubic bone to free the entire hindquarter

5 Step five, the closure (Figure 6), is done in the following manner

a Reconstruct an external inguinal ring for the passage of spermatic cord by selectively suturing the lower medial corner of the gluteus maximus aponeurosis to the rectus abdominis and the medial portion of the abdominal muscles

b The remaining gluteus maximus flap is sutured to the lateral portion of the abdominal muscles and the quadratus lumborum and psoas muscles

c After the insertion of soft rubber drains or plastic suction tubings, the skin and subcutaneous tissues are closed in the usual manner

RESULTS

Recurrence The incidence of recurrence of tumors following local resection is summarized in Table 4

Survival rates The overall short-term and long-term survival rates of our 19 patients are shown in Table 5

The comparison of the 5-year survival rates between malignant soft tissue tumors and malignant bone tumors is presented in Table 6

Table 6

Disease	Number of patients		5 year survival rate
	Dead	Living	
Malignant soft tissue tumors	4	6	60 %
Malignant bone tumors	7	2	22 2 %

DISCUSSION

Although hindquarter amputation is an extremely mutilating operation, it is still the only reliable way of completely eradicating malignant tumors from the buttock, hip and upper thigh *region*, provided that metastases have not yet taken place Our experience of a 42 per cent overall 5-year survival rate compares favorably with the published series *in* the medical literature which are shown in Table 7

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A STUDY OF RADIOGRAPHIC VARIATIONS OF THE HIP JOINT

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Anteroposterior radiographs of the pelvis were studied in 920 patients free of hip joint diseases The average joint space was between 3 and 4 mm in width Narrowing of the superior joint space was seen in 13 percent of the hips and may represent the earliest finding in osteoarthritis It was noted as early as the second and third decade in some patients Other changes noted were narrowing of the lateral joint space uniform narrowing of the space, an irregular joint space and tilting of the femoral head on the neck

Key words blurred eyebrow, CE angle, femoral head ratio; joint space narrowing

Accepted 5 vii 77

In most instances the etiology of osteoarthritis cannot be related to a specific injury or congenital malformation Congenital dysplasia, coxa vara, Perthes' disease, overt slipped epiphysis and protrusio acetabuli are some conditions recognized as precursors of osteoarthritis In order to cast some light on this problem a study was made of hip radiographs to determine what alterations exist in hips considered to be normal

In an effort to determine the earliest roentgenographic abnormalities which may lead to manifest osteoarthritis of the hip, the anteroposterior views of urograms in 920 patients were studied

Urograms were employed as they were the only available source of a large number of pelvic films showing the hip joints and because there is no known direct correlation between urinary tract diseases and degenerative joint disease of the hip joint

MATERIALS AND METHOD

The 920 urograms were selected at random from the radiographic files of the University of Pennsylvania Any film with established changes of osteoarthritis such as total joint narrowing sclerosis of the subchondral bone, osteophytes, cysts or irregular surfaces was discarded Any film in which a true anteroposterior projection was not made was also not used

The hips were reviewed with particular attention to the interspace distance between the head and the acetabulum and for changes in the acetabular and femoral surfaces Age, sex and race were known and the CE angle and interspace distance were measured

The joint space distance was measured on a vertical line through the geometric center of the head The narrowest joint space distance was also measured on a line passing through the geometric center (Figure 1) The CE angle was measured as described by Wiberg (1939)

Displacement of the femoral head on the neck was measured according to Murray (1965) using the "femoral head ratio", FHR A line was drawn from the most lateral part of the greater trochanter to the most medial part of the lesser trochanter and the center was determined The

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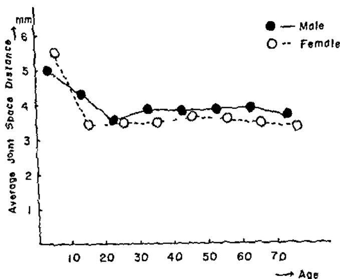


Figure 3 Joint space distance at different ages

incidence decreased significantly in the eighth decade The average for females was 10 7 percent The interesting features of this group were (1) This finding was first seen in the younger patients in the second or third decade and (2) in the older patients the finding was not associated with radiologic osteoarthritis (Table 1 and Figure 4)

2) *Lateral narrowed joint space*

The lateral joint space is between the lateral border of the acetabulum and head Narrowing of the lateral joint space was seen in 24 hips (1 3 percent) The narrowing was always found at the most lateral part of the joint, which is not in the major weight-bearing area Changes were first seen in the fourth decade and were present in each subsequent decade but did not increase significantly (Table 2) This finding was more common in females (Figure 5)

3) *Uniformly narrowed joint space*

The joint space was less than 2 mm in



Figure 4 Superior narrowed joint space on the left 20 year old white female had left superior narrowed joint space CE angle 25° Over the superior head joint space was 2 mm



Figure 5 Lateral narrowed joint space on the left 6[illegible] year-old white male had left lateral narrowed joint space CE angle 29° Lateral interspace was 1 mm

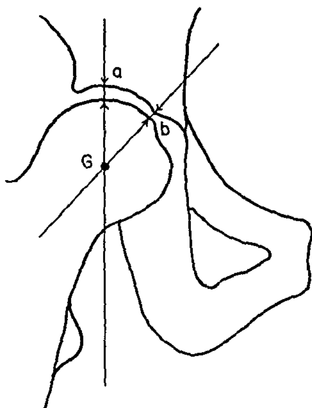


Figure 1 Measurement of joint space distance
a Joint space distance on the vertical line that passes the geometric center of the femoral head
b Joint space distance at the narrowest part
G Geometric center of the femoral head

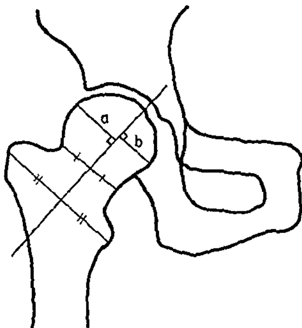


Figure 2 Femoral head ratio
$\frac{b}{a}$ = *Femoral head ratio*

center point at the narrowest part of the neck was also established and a line was then drawn connecting these two points and extending into the proximal femoral head The maximum distance to each side of the head is measured from this line, the most lateral distance expressed by 'a' and the most medial distance by b b a is called the femoral head ratio (*Figure 2*)

RESULTS

The average joint space distance measured on the vertical line "a" as in *Figure 1* was 3 8 mm in males (standard deviation 0 9 mm); in females the average was 3 5 mm (standard eviation 0 8 mm) A joint space of 2 mm or less was regarded as abnormal Individuals younger than 10 years showed a wider joint space than older individuals but few of our patients were in this age group The average joint space did not significantly diminish with age (Figure 3)

The variations noted were as follows

1) *A superior narrowed joint space*

This was the joint space measured at the narrowest part between the superior surface of the head and the acetabulum and corresponds to the oblique line 'b" drawn through the geometric center of the head as in Figure 1 This was the largest group deviating from the normal or average radiograph 236 of the 1840 hips were in this group (12 8 percent) The joint space was narrowest where the most prominent weight-bearing trabeculae passing from the head to the pelvis were found This point is usually located in the weight-bearing area at the superior part of the dome of the femoral head In males this change was first noted in the second decade The incidence increased gradually and reached a maximum in the fourth decade It decreased in the fifth and sixth decades, and its incidence again increased in the seventh and eighth decades The average for males was 14 9 percent

In females this narrowing was most common in the seventh decade and the



Figure 6 Uniformly narrowed joint space 20 year old white male had bilateral uniformly narrowed joint space CE angle right 24° left 34° Joint space distance right 2 mm left 2 mm Left hip is shown



Figure 7 Diffuse lateral acetabular edge (blurred eyebrow) 47 year old white male had hips with blurred eyebrow CE angle right 27° left 34° Joint space distance right 5 mm and left 4 mm Left hip is shown

three measurements along lines drawn through the geometric center on these films There were three male and four female hips in this group (Figure 6)

4) *Thickened and diffuse lateral acetabular edge (blurred eyebrow)*

These films showed an interesting loss of clarity of the lateral acetabular edge which was thickened in the para articular zone The thickened part was likened to an eyebrow covering the lateral femoral head The change was distributed rather uniformly in each decade being highest in the seventh in both sexes The total number of hips with this "blurred eyebrow" was 34 (1 8 percent) 21 in males and 13 in females (Table 3 and Figure 7)

5) *Changes in the shape of the femoral head*

Radiographs in this group revealed femoral heads which were assymmetrical in the anteroposterior plane This group differed from the superior narrowed the lateral narrowed or uniformly narrowed groups in that there were abrupt alterations of the joint space secondary to irregularity of the femoral head surface Five such hips were seen (0 3 percent) Three were in males two in females (Figure 8)

6) *Displacement of the femoral head*

When a femoral head deviated from the neck axis it was always in an inferior direction In each of these hips the femoral head ratio was greater than 1 35 indicating an inferior displacement Sev



Figure 8 Change in the shape of the femoral head 70 year old female with bilateral femoral head irregularity Interspace was 4 mm in both hips and CE angle was 36° in both hips Right hip is shown

Table 1 Superior narrowed joint space

	Age	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-89	Total
Male	Narrowed	0	2	6	20	16	30	44	23	141
	Hips in each age group	2	56	88	98	138	212	232	122	948
	%	0	3.6	6.8	20.4	11.6	14.2	19.0	18.9	14.9
Female	Narrowed	0	0	7	8	16	14	38	12	95
	Hips in each age group	8	48	132	114	172	170	146	102	892
	%	0	0	5.3	7.0	9.3	8.2	26.0	11.8	10.7

Table 2 Lateral narrowed joint space

	Age	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-89	Total
Male	Narrowed	0	0	0	2	0	0	2	2	6
	Hips in each age group	2	56	88	98	138	212	232	122	948
	%	0	0	0	2.0	0	0	0.9	1.6	0.6
Female	Narrowed	0	0	0	2	8	3	5	0	18
	Hips in each age group	8	48	132	114	172	170	146	102	892
	%	0	0	0	1.8	4.7	1.8	3.4	0	2.0

Table 3 Thickened and diffuse lateral acetabular edge (blurred eyebrow)

	Age	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-89	Total
Male	Narrowed	0	2	0	2	5	2	9	1	21
	Hips in each age group	2	56	88	98	138	212	232	122	948
	%	0	3.6	0	2.0	3.6	0.9	3.9	0.8	2.2
Female	Narrowed	0	0	1	2	0	4	4	2	13
	Hips in each age group	8	48	132	114	172	170	146	102	892
	%	0	0	0.8	1.8	0	2.4	2.7	2.0	1.5



Figure 6 Uniformly narrowed joint space 20 year old white male had bilateral uniformly narrowed joint space CE angle right 24° left 31° Joint space distance right 2 mm left 2 mm Left hip is shown



Figure 7 Diffuse lateral acetabular edge (blurred eyebrow) 47 year old white male had hips with blurred eyebrow CF angle right 27° left 34° Joint space distance right 5 mm and left 4 mm Left hip is shown

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	Hips in each age group	2	56	88	98	138	212	232	122	948
	%	0	3 6	6 8	20 4	11 6	14 2	19 0	18 9	14 9
Female	Narrowed	0	0	7	8	16	14	38	12	95
	Hips in each age group	8	48	132	114	172	170	146	102	892
	%	0	0	5 3	7 0	9 3	8 2	26 0	11 8	10 7

Table 2 Lateral narrowed joint space

	Age	0 9	10–19	20–29	30–39	40–49	50–59	60–69	70–89	Total
Male	Narrowed	0	0	0	2	0	0	2	2	6
	Hips in each age group	2	56	88	98	138	212	232	122	948
	%	0	0	0	2 0	0	0	0 9	1 6	0 6
Female	Narrowed	0	0	0	2	8	3	5	0	18
	Hips in each age group	8	48	132	114	172	170	146	102	892
	%	0	0	0	1 8	4 7	1 8	3 4	0	2 0

Table 3 Thickened and diffuse lateral acetabular edge (blurred eyebrow)

	Age	0 9	10 19	20–29	30–39	40–49	50 59	60 69	70–89	Total
Male	Narrowed	0	2	0	2	5	2	9	1	21
	Hips in each age group	2	56	88	98	138	212	232	122	948
	%	0	3 6	0	2 0	3 6	0 9	3 9	0 8	2 2
Female	Narrowed	0	0	1	2	0	4	4	2	13
	Hips in each age group	8	48	132	114	172	170	146	102	892
	%	0	0	0 8	1 8	0	2 4	2 7	2 0	1 5



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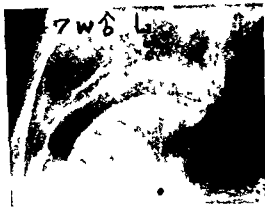


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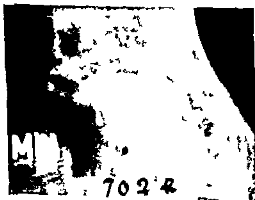


Figure 8 Change in the shape of the femoral head 40-year-old female with bilateral femoral head irregularity Interspace was 4 mm in both hips and CE angle was 36° in both hips Right hip is shown

Table 1 Superior narrowed joint space

	Age	0–9	10–19	20–29	30–39	40–49	50–59	60–69	70–89	Total
Male	Narrowed	0	2	6	20	16	30	44	23	141
	Hips in each age group	2	56	88	98	138	212	232	122	948
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Male	Narrowed	0	0	0	2	0	0	2	2	6
	Hips in each age group	2	56	88	98	138	212	232	122	948
	%	0	0	0	2.0	0	0	0.9	1.6	0.6
Female	Narrowed	0	0	0	2	8	3	5	0	18
	Hips in each age group	8	48	132	114	172	170	146	102	892
	%	0	0	0	1.8	4.7	1.8	3.4	0	2.0

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	Hips in each age group	2	56	88	98	138	212	232	122	948
	%	0	3.6	0	2.0	3.6	0.9	3.9	0.8	2.2
Female	Narrowed	0	0	1	2	0	4	4	2	13
	Hips in each age group	8	48	132	114	172	170	146	102	892
	%	0	0	0.8	1.8	0	2.4	2.7	2.0	1.5

Table 5 Incidence of bilateral ty

		Superior narrowed	Lateral narrowed	Uniformly narrowed	Acetabular change	Irregular fem head	Head tilt
	No of bilat pt	59	1	1	6	1	1
Male	*No of pt*	*82*	[illegible]	2	15	2	6
	%	72 0	20	50	40	50	16 7
	No of bilat pt	46	3	1	4	1	0
Female	No of pt	49	15	3	9	1	0
	%	93 9	20	33 3	44 4	100	0

second and third decades If a subtle narrowing is a harbinger of joint disease in later life, it should be possible to identify the individuals who may develop this condition at an early age The narrowed area coincides with the weight-bearing area where prominent trabeculae straddle the joint

The shifting of the femoral head relative to the neck has been described by Murray (1965) as a tilt deformity and he felt this could be the result of a minimally slipped capital epiphysis Five hips showed such a deformity which may well lead to an osteoarthritis

The blurred eyebrow was seen in two percent of the hips The pathology of this condition has not been described to our knowledge It would appear to be a very early stage of subchondral sclerosis perhaps related to alteration of weight bearing stresses with a lateral shift of the weight bearing axis

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Figure 9 Displacement of femoral head on the neck 58 year old white male both femoral heads deviate inferomedially CE angle right 27°, left 25° FHR right $^{34}/_{25}$ = 1 36 left $^{34}/_{24}$ = 1 42 Left hip is shown (FHR of more than 1 35 shows tendency for inferomedial displacement of the femoral head)

en hips showed a change of this type (0 4 percent) All were in males (Figure 9)

In 141 male hips in which none of the above abnormalities were noted the average CE angle was 32° (standard deviation 6 6°) The minimum was 15° and the maximum 47° In 95 female hips showing no abnormalities, the CE angle was 35° (standard deviation 7 4°) The minimum was 19° and the maximum 56° In both male and female hips showing a superior narrowed joint space no significant change in CE angle was noted No correlation could be made between the CE angle and the other abnormalities studied (Table 4)

DISCUSSION

Degenerative joint disease of the hip is associated with a narrow, irregular joint space in the advanced state In this study 85 percent of the hip joints showed a uniform joint space without local narrowing Superior joint space narrowing occurred in 13 percent of the hips (in 82 percent of these hips, it was bilateral) Bilaterality of the other hip variations was not common (Table 5) This narrowing was more common in the older age groups and may be an early stage of degenerative joint disease If this type of narrowing is a precursor of an osteoarthritis, it may develop at an early age in some individuals as it was seen in the

Table 4 CE angle versus each group of variations noted

		No of hips	Min	Av	S D	Max
	Normal male	141	15°	32 0°	6 6°	47°
	Normal female	95	19	35 0	7 4	56
	Superior narrowed male	141	18	31 2	7 3	55
1	Superior narrowed female	95	14	33 2	6 7	56
2	Lateral narrowed	24	16	32 4		42
3	Uniformly narrowed	7	20	37 4		46
4	Blurred eyebrow	34	23	33 4		56
5	Change in femoral head shape	5	25	30 7		36
6	Displacem of the femoral head on the neck	7	23	29 2	–	37

Av Average

S D Standard deviation

Table 1 Age distribution and type of fracture

Age (years)	Total number	Male	Female	Type of fracture Pauwels I	Pauwels II	Pauwels III
10–39	6	6			2	4
40–65	21	6	15	8	7	6
over 65	33	10	23	5	20	8
Total	60	22	38	13	29	18

females mean ages 53 (range 15 to 85) and 68 (range 40 to 88) years respectively (Table 1) The fractures were classified according to Pauwels (1935) Stable fractures belonging to Pauwels group I were displaced or wedged into a valgus position (13 patients) and unstable ones belonging to Pauwels group III were displaced into varus (18 patients) Pauwels group II (29 patients) contained both stable and unstable fractures in a neutral or anatomical position

Preoperative treatment

All patients were treated with traction before the operation in order to preserve the circulation and the vascular supply to the hip joint and also to alleviate the pain Preoperative treatment was given to patients with congestive heart disease hypertension or infections of the respiratory tract

Operative technique

The fracture was reduced on the operating table under general anesthesia with the aid of an X ray television screen Through a small incision in the trochanteric region two thin Smith Petersen nails were introduced along guide pins hammered into the correct position and the guide pins were removed The correct placement of the nails is demonstrated in Figure 1 A D

Aftertreatment

Fifty six patients were mobilized on the day after the operation In 15 cases mobilization was delayed because of poor general health or concomitant diseases Weight bearing on the operated extremity was allowed within a few days in 56 cases on the day after the operation

Complications

One patient died 7 days after the operation of a heart infarction and eight patients died within 2 years of the operation from other causes These patients were excluded from the series Two cases of postoperative infection were registered and in four cases the operative technique was considered to be imperfect

Follow-up

Thirty three patients were hospitalized for less than 3 weeks and 22 between 3 and 4 weeks (Table 2) All of the patients were followed up for more than 2 years The follow up period was 2 3 years in 30 cases 3–4 years in 27 cases and more than 4 years in 3 cases (Table 3)

Table 2 Duration of hospital treatment

Duration (weeks)	Total no of patients	Patients in different age groups 10–39 years	40–65 years	over 65 years
1	3		3	
2	31	2	12	17
3	17	1	4	12
4	5	2		3
6–7	4	1	2	1
Total	60	6	21	33

Table 3 Follow-up period

Follow up (months)	No of patients
24–35	30
36–47	27
over 48	3
Total	60

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SUBCAPITAL FRACTURES OF THE FEMUR TREATED WITH TWO THIN SMITH-PETERSEN NAILS

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The results of treatment of 71 patients with subcapital fractures of the femur, fixed with two thin Smith-Petersen nails, are presented after a follow-up time of between 2 and 4 years Excellent results of treatment were achieved in 39 out of 60 cases and good results in 11 cases Six cases of ischemic necrosis of the femoral head were recorded, and there were four cases with pseudarthrosis of the femoral neck one developed because of postoperative infection and three were attributed to an imperfect operative technique The method is recommended for subcapital femoral neck fractures amenable to closed reduction and internal fixation Pseudarthrosis may be prevented by good reduction of the fracture and a careful nailing technique

Key words femoral neck fractures, fracture fixation, internal fixation

Accepted 23 vi 77

In the treatment of subcapital fractures of the femur, primary endoprosthesis has been advocated because of the high incidence of late capital necrosis (Trueta 1968) Other surgeons have preferred nailing, claiming that retention of the patient's own femoral head is better than an endoprosthesis (Barnes 1967, Bentley 1968, Garden 1964, Massie 1973, Nicoll 1963) This has focused attention on the methods of nailing, which in turn has resulted in new procedures of fixation (Barnes 1967, Garden 1961, Massie 1964, 1973, Smyth et al 1964) A good surgical technique is most important (Garden 1964) Therefore, the method of nailing should be technically simple, but at the same time a good fixation should be achieved The method presented in this paper—fixation with two thin Smith-Petersen nails—seems to fulfill these demands

MATERIAL

The material includes the first 71 consecutive cases of subcapital fractures of the femur fixed with two thin Smith Petersen nails made of Vitallium These nails were originally intended for fixation of femoral neck fractures in children In the belief that two nails could prevent the appearance of pseudarthrosis which was often seen following fixation of the fracture with one ordinary Smith Petersen nail, this fixation technique was adopted in our clinic in 1970 (Riska & Ivstilainen 1973)

The follow up period was insufficient in nine patients who died within 2 years of the operation and in two patients who emigrated These 11 patients were excluded from the series Of the remaining 60 patients, 22 were males and 38

Table 4 Results of treatment

Result	Total no of patients	Patients in different age groups			Type of fracture		
		10–39 years	40 65 years	over 65 years	Pauwels I	Pauwels II	Pauwels III
Excellent	39	5	14	20	9	21	9
Good	11	1	3	7	2	5	4
Fair	3		2	1	1	1	1
Poor	7		3	4	1	2	4
Total	*60*	*6*	*22*	*32*	*13*	*29*	*18*

RESULTS

Results were classified into excellent, good, fair, and poor according to the following criteria

Excellent The patient walked without a limp and there was no pain The union of the fracture was good without signs of ischemic necrosis of the femoral head

Good The hip joint was pain-free but the patient had to use a stick when walking outdoors, and had a very slight limp The fracture was well united without signs of ischemic necrosis of the femoral head

Fair The patient had to use a stick when walking because of pain in the hip joint The mobility of the joint was reduced X-rays showed delayed union of the fracture, or early signs of ischemic necrosis of the femoral head

Poor The patient used a stick when walking and there was pain in the hip joint both when walking and standing The mobility of the hip joint was reduced X rays showed development of a pseudarthrosis or ischemic necrosis of the femoral head The operative technique was imperfect

An excellent result of treatment was recorded in 39 cases with good union of the fracture without signs of ischemic necrosis of the femoral head (Table 4) In 11 cases the result was classified as good In one of these, a man of 39 with a Pauwels group III fracture, slight pain in the hip joint was present at the last follow-up examination 2 years and 8 months after the operation because of incipient ischemic necrosis of the femoral head, verified by tomography Postoperative infection in one case resulted in the development of a pseudarthrosis and the result of treatment was classified as poor (Table 4) An imperfect operative technique in one case resulted in delayed union of the fracture with a painful hip joint The result was classified as fair Pseudarthrosis of the femoral neck developed in three additional cases giving a poor result, in one case because of poor reduction of the fracture, and in two cases because of an imperfect nailing procedure Ischemic necrosis of the femoral head was registered in altogether five cases The result of treatment was classified as fair in two cases and as poor in three cases All four cases with pseudarthrosis and the three cases with ischemic necrosis of the femoral head were later treated with endoprosthetic surgery

DISCUSSION

Meticulous attention to surgical technique and good postoperative care are required in the treatment of subcapital fractures In our clinic, Nyström nails were previously used for internal fixa-



Figure 1
Radiographs of a 59 year old man with a Lanuels group II type fracture of the femoral neck treated by two thin Smith Petersen nails A B Before operation C D Two years and three months after the operation

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TOTAL HIP REPLACEMENT IN ANKYLOSING SPONDYLITIS

HALLDÓR BALDURSSON, HÅKAN BRATTSTRÖM & TORD H OLSSON

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Eighteen total hip replacements were performed in 10 patients with ankylosing spondylitis The mean observation time was 3 8 years Seven hips had been operated on before total hip replacement (THR), 6 were ankylotic before THR The results as regards pain relief and increased walking distance were good All hips improved in mobility after THR and this improvement was maintained during the observation time Six of the 10 patients went back to full time work The differences between patients with ankylosing spondylitis and rheumatoid arthritis, as regards indications for and rehabilitation after THR are discussed

Key words ankylosis arthritis rheumatoid arthroplasty, hip rehabilitation sex spine rigid, spondylitis ankylosing, vital capacity young patients

Accepted 16 iv 77

Hip involvement is common in ankylosing spondylitis (AS) and often leads to ankylosis of the hips (Dwosh et al 1976) In AS the spine is usually very rigid, and therefore the decrease in hip mobility cannot be compensated for by movements of the spine Cup arthroplasty has been tried in ankylosing spondylitis but seems to give disappointing results (Law 1952, Johnston & Larson 1969 Brattstrom et al 1974)

It is generally realized that the problems of total hip replacement (THR) in the rheumatic diseases are different from the problems of THR in osteoarthrosis However, it is not always appreciated that patients with AS differ in many ways from patients with rheumatoid arthritis (RA) as regards indications for and rehabilitation after THR

1 Patients with AS are usually young and physically more active than patients with RA This makes postoperative rehabilitation easier but on the other hand means that the prosthesis will be subjected to greater stresses

2 In AS, the upper extremities are usually in good condition, which means that the patients can use walking aids effectively and are often able to walk in spite of very bad hips

3 Stiffness is often a greater problem than pain By the time hip surgery is needed in AS, the spine is usually quite rigid, which makes the patient very dependent on hip movement for sitting, picking up objects from the floor etc

4 Vital capacity is reduced because of involvement of the costovertebral joints This may cause problems during or after general anaesthesia and may limit walking after hip replacement

5 Improvement in range of motion after THR may be small (Arden et al 1970,

tion of subcapital fractures (Nystrom 1954) but these were inserted into the femoral neck without guide pins and were therefore replaced by two thin Smith-Petersen nails The results of treatment using this nailing technique were excellent or good in 50 out of 60 patients and good union of the fracture was seen in 56 Six cases of incipient aseptic necrosis of the femoral head were recorded after a follow-up of 2–4 years However, it may not be possible to avoid, in some cases, the development of late capital necrosis years after the fracture, because this is dependent on the type of fracture and maybe on subsequent overstrain of the hip joint (cf. Massie 1973)

In three cases an imperfect operative technique resulted in the development of pseudarthrosis, but this can be avoided by good operative technique Weight-bearing on the operated limb was allowed on the day after the operation and the hospital stay was less than 3 weeks in 51 cases In addition, the general condition of the patients was not affected by the nailing procedure, which can easily be carried out, under local anesthesia, if necessary Thus, if a subcapital fracture of the femoral neck is amenable to closed reduction and internal fixation, this method with two thin Smith-Petersen nails may well be a reasonable choice

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TOTAL HIP REPLACEMENT IN ANKYLOSING SPONDYLITIS

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Key words ankylosis arthritis rheumatoid arthroplasty hip rehabilitation sex spine rigid spondylitis ankylosing vital capacity, young patients

Accepted 16 iv 77

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5 Improvement in range of motion after THR may be small (Arden et al 1970,

Year	Authors	Reviewed Pat	Reviewed Hips	Observation time	Results: Pain relief	Results: Range of motion	Results: Walking	Ankylosis (hips) Pre op	Ankylosis (hips) Post op	Comments
1969	Buchholz	12	20	?	No pain before or after THR	Improved	Improved	20	none	
1970	Arden et al	5	9	> 6 months	71.5 per cent good or excellent		Not evaluated	?	none	Results graded according to range of flexion and presence of pain
1970	Welch & Charnley	20	33	> 1 year	100 per cent	Sum total hip motion > 100° in all hips post op	Improved	13	none	
1972	Arden et al	7	10	> 1 year	80 per cent good or excellent		Improved	2 or more	none	
1972	Harris et al		9	> 3 months	78 per cent good or excellent		Not evaluated	?	none	
1972	Wilde et al	1	1	4 months				1	1	Reports a case of reankylosis after THR. Hip previously operated with cup arthroplasty
1973	Buchholz & Noack	26	41	> 2 years	Good	Improved	Improved	?	?	
1975	Halley & Charnley	9	17	> 6 months	100 per cent	88.2 per cent > 100° sum total hip motion post op	Improved	?	none	82.4 per cent had less than 30° sum total hip motion before THR
1976	Bisla et al	23	34	> 1 year	Good	Satisfactory in 58.6 per cent	Improved	21	2	
1976	Resnick et al	8	16	> 1 year in 14 hips		Poor		1	5 on X ray 3 on clinical examination	All 3 hips showing clinical reankylosis had previous surgery. Three out of 5 hips with radiological reankylosis ha[illegible]

Table 2 Details about patients

Pat no	Sex	Side	Age at op (years)	Duration of disease at op (years)	Previous operation	Ankylosis before THR	Grade according to the method of Merle d'Aubigné & Postel See also Table 3						Observation time (years)
							Before THR			At follow-up			
							Pain	Walking	Mobility	Pain	Walking	Mobility	
1	M	R	not op	—			—	—		—	—	—	—
		L	61	20	—	—	1	2	4	6	5	6	2 3
2	M	R	55	29			3	2	1	6	5	4	4 3
		L	55	29			3	2	1	6	5	4	4 2
3	M	R	40	20	—	—	3	2	4	6	5	5	2 7
		L	38	18	—	—	3	3	3	6	5	5	4 8
4	F	R	35	11	cup		1	1	3	6	1	4	3 5
		L	35	11	cup	-	1	1	3	6	1	4	3 4
5	M	R	35	15	—		3	2	3	6	3	5	2 6
		L	35	15	synovectomy		3	3	3	6	3	5	2 8
6	M	R	not op	-	—	—	—	—	—			—	—
		L	30	10	synovectomy		1	3	1	6	4	5	4 2
7	M	R	23	9	cup	+	6	2	1	6	1	4	5 0
		L	23	9	—	+	6	2	1	6	4	4	5 2
8	M	R	20	6	—	+	1	2	1	6	1	4	4 5
		L	20	6		+	3	2	1	6	4	5	4 4
9	M	R	20	11	—	—	3	1	2	6	4	5	4 6
		L	23	14	synovectomy	+	6	3	1	6	4	5	2 2
10	F	R	18	6	-	+	6	2	1	3	4	5	5 8
		L	20	8	cup	—	3	2	4	6	4	6	2 7
			mean = 32 years	mean = 14 years									mean = 3 8 years

Men 8 patients 14 total hip replacements
Women 2 patients 4 total hip replacements
Total 10 patients 18 total hip replacements

Arden et al 1972) and may not last Some authors warn against the risk of re-ankylosis after hip surgery in AS (Dwosh et al 1976, Resnick et al 1976)

In most reported series, a few THRs in AS are reported together with a much greater number done in RA, osteoarthrosis and miscellaneous other diseases It is usually impossible to see what difference, if any, there is between the results in the different diagnostic categories Some earlier reports on THR in AS are listed in Table 1 All these reports except three (Wilde et al 1972, Bisla et al 1976, Resnick et al 1976) include THRs done in diseases other than AS but we have tried to separate the results according to diagnoses

In this study, patients with AS who had undergone THR were examined to assess the results of the operation and to find out especially whether hip range of motion had been improved and whether any improvement of this kind had been maintained

PATIENTS AND METHODS

Patients

Eleven patients with AS underwent THR in the Department of Orthopaedic Surgery of the University Hospital in Lund from September 1971 to October 1974 The patients were treated in cooperation with the Department of Rheumatology

One patient died of a myocardial infarction 6 months after THR and is not included in this study The others were last examined by one of the authors (Baldursson) in the autumn of 1976 The mean observation time was 3 8 years with a minimum of 2 2 years Further details about the patients are given in Table 2 Of special interest is the mean age only 32 years

Indications

Indications for THR were as follows

Pain at rest	4
Pain and reduced range of motion	10
Ankylosis without pain	4
Total	18 hips

Before THR was decided upon the patient and the team thoroughly discussed the patient's problems and the patient was informed about the expected improvement and the risks connected with the operation

Operation

General anaesthesia was used In 11 operations an endotracheal tube could be passed but in seven operations a mask and a pharyngeal tube had to be used No tracheostomies were done

The operations were done in an ordinary operating room Prophylactic anticoagulant treatment was not given An anterolateral incision was used in 16 operations and a posterolateral incision in two operations The greater trochanter was not detached The neck of the femur was divided with an osteotome usually in situ An adductor tenotomy was done in four hips and a tenotomy of the iliopsoas in six hips The operating time was 120–205 minutes with a mean of 150 minutes This is longer than the average operating time for THR in osteoarthrosis Many of the THRs reported here were technically difficult because of scarring from previous operations or because of ankylosis A McKee Farrar prosthesis was used in 17 hips and a Howse prosthesis in one (left hip of patient no 9 Table 2)

In five THRs cloxacillin was given before operation and continued after operation In 12 THRs antibiotics were given only after the operation In six of these penicillin was used cloxacillin in five and tetracycline in one In one THR no antibiotics were given

Time in hospital

The stay in hospital after operation was from 14 to 86 days with a mean of 39 days This includes the time spent in a rehabilitation clinic by some patients who were sent there upon their discharge from the department of orthopaedic surgery

Complications

There were no complications related to the anaesthesia One patient had a postoperative haematoma which was evacuated Four hips had superficial infections all of which healed

RESULTS

The results were assessed according to *clinical findings* i e, pain (Table 4), walking ability (Table 5), mobility (Table 6) and functional capacity (Table 7) and *radiological findings*

With regard to pain walking ability

Table 3 Hip grading according to d Aubigné & Postel

Grade	Pain	Function (walking ability)	Mobility (degrees)
1	Severe and spontaneous	Few yards or bedridden two canes or crutches	0—30
2	Severe on attempting to walk, prevents all activities	Time and distance very limited with or without canes	31—60
3	Tolerable permitting limited activities	Limited with one cane difficult without cane able to stand long periods	61—100
4	*Only* after some activity disappears quickly with rest	Long distance with one cane limited without a cane	101—160
5	Slight or intermittent pain on starting to walk less with activities	No cane but a limp	161—210
6	No pain	Normal	211—260

and mobility, the hips were graded ac cording to the method of d Aubigné & Postel (1954) in the form used by Halley & Charnley (1975) except that alphabetic prefixes were not used By this method hip mobility is assessed as the sum of flexion, extension abduction adduction, internal rotation and external rotation

Pain Four hips were pain free before

Table 4 Pain assessed according to the method of d Aubigné & Postel See also Table 3

After THR						
6	4		10			3
5						
4						
3						1
2						
1						
Grade	1	2	3	4	5	6

Before THR

Above diagonal line = improved	14
On diagonal line = *unchanged*	3
Below diagonal line = worse	1
Total	18 hips

Table 5 Walking ability assessed according to the method of d Aubigné & Postel See also Table 3

After THR						
6						
5		4	1			
4		4	3			
3		3	1			
2						
1	2					
Grade	1	2	3	4	5	6

Before THR

Above diagonal line = improved	15
On diagonal line = unchanged	3
Below diagonal line = worse	0
Total	18 hips

THR These four hips were ankylotic and, in three, a bony ankylosis was pres ent At the time of the last examination, 17 hips were pain-free One hip is painful at rest and on weight bearing The cause of the pain, which started 3 years after THR, is still not clear, but late infection must be suspected

Arden et al 1972) and may not last Some authors warn against the risk of re-ankylosis after hip surgery in AS (Dwosh et al 1976, Resnick et al 1976)

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With regard to pain, walking ability

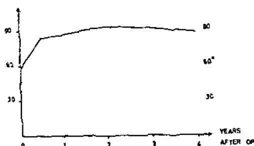


Figure 1 Mean arc of flexion in the 12 hips where some mobility was present before THR

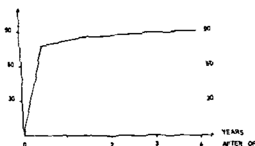


Figure 2 Mean arc of flexion in the 6 hips that were ankylotic before THR

Figure 2 shows in the same way the arc of flexion during the observation time in the six hips that were ankylotic before THR There was also a relatively rapid increase in mobility in these hips during the first 6 months and after that there

Th

upor

as well as the others during the observation time

Functional capacity Before THR all patients except one were in functional class II according to the classification of the American Rheumatism Association (Steinbrocker et al 1949) but they almost qualified for class III because of hip pain stiffness or deformity

Six of the 10 patients were working full time at follow up One patient was working part time One patient is studying at a university and is expected to work full-time after graduation Of the two patients left, one is a 64-year old retired farmer and the other is a 38-year-old housewife incapacitated by general ill health and multiple joint symptoms

Radiological findings

The radiographs were examined by one of the authors (T H O) with special attention to signs of loosening, infection and ectopic calcifications

The period of radiological follow-up was between 1 8 and 5 8 years with the exception of one patient (No 9) who was last X-rayed 0 9 years after his last hip replacement

The so-called zone about the cement did not exceed 2 mm in any of the hips There was no case of ankylosis postoperatively Small calcifications were found laterally to the femoral neck in five cases No radiological signs of infection were found Fracture of the plastic cement around the femoral stem was found in one hip (patient no 2, left hip) This indicates that movement may occur between the prosthesis and the cement in this hip, but as the patient is symptom-free and 60 years old reoperation is not indicated

In another case (patient no 3, right hip) the femoral part of the prosthesis, with its plastic cement intact, has moved 5 mm in a caudal direction in relation to the femur

DISCUSSION

Our experience of THR in AS has been encouraging In contrast to RA patients, AS patients rarely have serious involvement of peripheral joints other than the hips This, in addition to their young age, means that many AS patients can be rehabilitated to a gainful occupation, whereas, in the case of the RA patients, one must often be content with a pain-free and mobile hip and must accept that the ability to work is unchanged by THR

Walking ability. Table 5 shows the improvement in walking ability after THR. Before THR, the limiting factor was hip pain or stiffness. After THR, the limiting factor in at least three patients was poor respiratory function.

In our clinic, patients with THR are advised not to "throw away the cane", but some patients find the cane unnecessary or that it interferes with their work especially if the work includes walking and carrying. This means that in practice the is no sharp dividing line between grade 4 and 5 (with or without a cane).

Mobility. Six hips were ankylotic before THR. The word "ankylotic" is used to denote absolute absence of movement on clinical examination. Three more hips had only minimal movement, less than 30° total movement in all directions.

The movement of extension-flexion is the most important one of the hip movements. This is also the hip movement that is easiest to measure and where the least error of measurement may be expected. We have therefore selected the arc of flexion to represent hip movement and Figure 1 shows the mean arc of flexion before THR and during the observation time in the 12 hips where some mobility was present before THR. The mean arc of flexion before THR was 58° in these 12 hips. After THR, there was a gain in movement during the first 6 months and after that the mobility was practically unchanged during the observation time.

Table 6. Mobility assessed according to the method of d'Aubigne & Postel. See also Table 3.

After THR						
6				2		
5	4	1	2	1		
4	5		3			
3						
2						
1						
Grade	1	2	3	4	5	6

Before THR

Above diagonal line = improved	18
On diagonal line = unchanged	0
Below diagonal line = worse	0
Total	18 hips

Table 7. Functional capacity according to the classification of the American Rheumatism Association (Steinbrocker et al. 1949).

		Before hip replacement	After hip replacement
Class I	Complete functional capacity with ability to carry out all usual duties without handicap		5 patients 9 hips
Class II	Functional ability adequate to conduct normal activities despite handicap of discomfort or limited mobility of one or more joints	9 patients 16 hips	4 patients 7 hips
Class III	Functional capacity adequate to perform only little or none of the duties of usual occupation or self care		1 patient 2 hips
Class IV	Largely or wholly incapacitated with patient bedridden or confined to wheelchair permitting little or no self care	1 patient 2 hips	

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Sexual problems are common with these young patients, as in other diseases where hip pain and stiffness occur (Currey 1970, Todd et al 1973) THR can be a great help by removing hip pain and stiffness, thus making it physically possible for the patient to have a normal sex life However, the patient's worries and hopes often remain unspoken and so are unknown to the surgeon, who rarely directs his questions towards sexual matters when discussing the patient's problems Instead, the discussion centres on other aspects of hip function, such as walking and sitting, which the patient may in fact be less concerned about As the patient and the surgeon have not discussed the sexual aspects of THR, there may remain unsolved problems that could have been solved easily and quickly by informing the patient For instance, a female patient may abstain from sexual intercourse because of unnecessary fear of damaging her prosthesis

As regards pain relief and improvement in ability to walk, the results are comparable to the results of THR in other patient categories All hips have improved in range of motion and, what is interesting, have maintained that improvement during the observation period The hips that had been operated upon before or were ankylotic before THR were no exceptions In some cases where a patient for some reason did not exercise, a temporary decrease in hip mobility was seen The mobility could in all instances be brought up to the previous level by a period of intensive training We consider that the most important factor in preventing deterioration of hip mobility after replacement is patient instruction and regular supervision, preferably by a team consisting of an orthopaedic surgeon, a rheumatologist and a physiotherapist The improvement in range of motion by THR can be maintained, but this means a great deal of hard work for the patient and perhaps for the physiotherapist, who must see the patient regularly If poor vital capacity seems to limit the patients walking distance, breathing exercises may be useful and should be tried

Total hip replacement can be very important in the rehabilitation of patients with AS, but it must be remembered that these young and active patients with their rigid spines do not treat their prosthesis gently and are very dependent upon hip mobility They must be kept under supervision for a long time after THR, probably for the rest of their lives both to discover complications (e g loosening or fracture of the prosthesis) in time and also to see that mobility of the replaced hips is maintained

ACKNOWLEDGEMENTS

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Figure 1 Sinogram of right hip showing cavity around neck of femoral prosthesis Note calcified mesenteric nodes



Figure 2 Sinogram of right hip defining branching sinus

negative for tubercle bacilli The patient was treated with intramuscular Streptomycin 0 5 g daily for 2 months and Rifampicin 450 mg daily and Isoniazid 300 mg daily (to be continued for 18 months) Eight weeks after beginning anti tuberculous therapy the groin sinus was healed and the ESR had fallen to 45 mm/hour It fell to 23 mm hour after 6 months of the therapy She had 70° of active hip flexion and was able to walk with little pain

DISCUSSION

A case of tuberculosis arising in a joint that had undergone prosthetic replacement is described It is assumed that the tuberculous infection in the hip developed following a bacteraemia secondary to activation of a latent tuberculous focus almost certainly in the mesenteric glands That the hip contained a prosthesis may have made it susceptible to bacteraemic infection At the original arthroplasty operative findings were consistent with osteoarthritis though the possibility of tuberculosis of the proximal femur has to be considered It should be noted that healing of the sinus occurred without necessitating removal of the prosthesis Although rare tuberculosis should be excluded as a cause of delayed infection in a joint which contains a prosthesis

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TUBERCULOSIS AS A LATE COMPLICATION OF TOTAL HIP REPLACEMENT

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A case of tuberculosis developing in a hip joint which had undergone total prosthetic replacement arthroplasty 7 years previously is described. The patient had no manifestation of active systemic tuberculosis although calcified mesenteric nodes were noted on abdominal X ray. *It is assumed that hip joint infection occurred during a bacteremia following activation of a latent tuberculous focus in the mesenteric lymph nodes*

Key words tuberculosis hip arthroplasty

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Delayed infection of joints that have undergone prosthetic replacement arises following contamination at the time of original surgery (Charnley & Eftekhar 1969) or from metastatic spread from a septic focus elsewhere in the body (Hall 1974 Parsons 1971) A case of tuberculosis developing in a hip joint in which a total hip prosthesis had been inserted 7 years previously is described No similar case can be found on review of the literature

CASE REPORT

In March 1968 a 70 year old lady underwent a right Ring total hip replacement for osteoarthrosis Operative findings revealed eburnation of the femoral head and a shallow worn acetabulum When reviewed in December 1969 she had a good range of pain free movements of the hip

In November 1975 she presented with a 4 cm swelling in the right groin lateral to the femoral artery and attached to the underlying muscles At operation the swelling found to lie between sartorius and pectineus could not be enucleated but its caseous *contents were evacuated* The cyst wall and its contents were sterile on routine bacteriological culture and tubercle bacilli were not cultured or seen on Ziehl Nielsen stain although the operative findings suggested a psoas abscess Histology revealed non specific chronic inflammation X ray of the lumbar spine was normal Postoperatively the patient developed a pyrexia and a purulent discharge from the wound *Staph pyogenes* being cultured

Four weeks postoperatively despite therapy with cloxacillin there was a persistent staphylococcal discharge from the groin wound A sinogram (Figures 1 and 2) defined a branching sinus arising from a cavity adjacent to the head of the Ring prosthesis On January 22nd the sinus was biopsied and laid widely open the deep tract being followed to the junction of the femoral neck and its prosthesis The tissue was sterile on routine culture and histology revealed non *specific subacute inflammation*

The patient s hip remained extremely irritable and her ESR was raised to 100 mm/hour Six weeks after the sinus exploration Myco tuberculosis was isolated *on culture from the biopsied* sinus wall and acid/alcohol fast bacilli were also identified by Ziehl Nielsen stain A Heaf test was strongly positive (Grade III) and calcified mesenteric nodes *were noted* on X ray in the right iliac fossa Chest X ray was clear and sputum and early morning urine specimens were

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LOAD BEARING CHARACTERISTICS OF THE PATELLO-FEMORAL JOINT

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This study of normal patello femoral biomechanics defines some functional specifications which may be useful in future total knee prosthesis design. Serial lateral X rays of 15 fresh knees and their patellar mechanisms at several flexion angles provided definition of the direction of the resolved patello femoral forces. Assuming that the patella acts as a frictionless pulley, the magnitude of the patello femoral forces during several activities was calculated using data from Morrison (1970) and Smidt (1973). It ranged between 421 and 3420 newtons for the various activities and for isometric exercise. A methylene blue contact print technique was used to measure the bearing areas. These data indicate that between 13 and 38 per cent of the patellar surface bears joint loadings. Patello femoral contact stresses were calculated to range from 1.28 to 12.6 N/mm². A 696 newton man climbing stairs would, for example, generate a patello femoral force of 1754 newtons and would experience patello femoral contact stresses between 3.73 and 6.87 N/mm². Stress values were equal to or in excess of anticipated tibial femoral stresses. The high patello-femoral load values, the small bearing surfaces, and the consequent significant stress magnitudes indicate the need for caution in development of a patello femoral joint prosthetic replacement.

Key words: biomechanics, knee joint, knee joint forces, patella prosthesis

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patello-femoral articulation may detract from the expected relief of pain after these procedures. Rational design considerations in the development of a prosthesis which addresses this problem require knowledge not only of the anatomy of the joint, but also of the functional stresses normally present across the bearing surfaces. Although considerable information is available regarding the anatomy, biomechanics, and pathology of the patello-femoral articulation, we were unable to find adequate published experimental values for patello-femoral contact areas and for contact stresses at

This paper was presented in part at the 1975 meeting of the Orthopaedic Research Society in San Francisco, California.

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This study of normal patello femoral biomechanics defines some functional specifications which may be useful in future total knee prosthesis design Serial lateral X rays of 15 fresh knees and their patellar mechanisms at several flexion angles provided definition of the direction of the resolved patello femoral forces Assuming that the patella acts as a frictionless pulley the magnitude of the patello femoral forces during several activities was calculated using data from Morrison (1970) and Smidt (1973) It ranged between 421 and 3420 newtons for the various activities and for isometric exercise A methylene blue contact print technique was used to measure the bearing areas These data indicate that between 13 and 38 per cent of the patellar surface bears joint loadings Patello femoral contact stresses were calculated to range from 1 28 to 12 6 N/mm² A 696 newton man climbing stairs would for example generate a patello femoral force of 1754 newtons and would experience patello femoral contact stresses between 3 73 and 6 87 N/mm² Stress values were equal to or in excess of anticipated tibial femoral stresses The high patello femoral load values the small bearing surfaces and the consequent significant stress magnitudes indicate the need for caution in development of a patello femoral joint prosthetic replacement

Key words biomechanics knee joint knee joint forces patella prosthesis

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Most available total knee joint prostheses treat only the tibial femoral portion of the knee joint Residual pathology at the patello-femoral articulation may detract from the expected relief of pain after these procedures Rational design considerations in the development of a prosthesis which addresses this problem require knowledge not only of the anatomy of the joint but also of the functional stresses normally present across the bearing surfaces Although considerable information is available regarding the anatomy, biomechanics and pathology of the patello femoral articulation we were unable to find adequate published experimental values for patello-femoral contact areas and for contact stresses at

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ure 4 Typical tographs of specimens 4 single contact area 30° knee flexion The number of contact a leterminatic ns that re possible for one ecimen is shown



walking up and down a one to six ramp and going up and down stairs Similar isometric quadriceps forces at defined knee flexion angles have been reported by Smidt (1973) These values were used to calculate the patello fem oral con tact forces in Table 1

In order to determine contact stress direct measurement of the patello femoral contact areas was necessary For our 15 fresh specimens the patella was surgically released from its medial and lateral proximal capsular attach ments It was painted with methylene blue or red instrument ink A desired knee flexion angle was selected The patella was returned to its normal position for the selected angle and secured in position with manual tension on the quadriceps aponeurosis A force of 25 kg was then manually applied normal to the patello femoral contact point and coaxial with the pre determined patello femoral force vector F_{pt} The resulting contact print (Figure 4) of the force bearing area was photographed

A lens to object distance of 18 inches was used for all photographs A centimeter ruler was positioned level with the area of interest and included in all photographs Multiple exposures were made of each specimen to be sure that the contact areas of interest would be perpendicular to the focal axis The resulting slides were en larged until the centimeter markings on the ruler could be superimposed on centimeter graph paper The contact areas were traced and the areas enclosed by the tracings were determ ned by planimetry

Although Aglietti et al (1975) have reported that in a limited number of experiments on two specimens patello femoral areas were only slightly affected by increases in quadriceps force we were concerned that due to the deform ability of articular cartilage our manually applied patello femoral load of 25 kg was non physiologic and that our measured contact areas might be smaller than those experienced by the knee during normal activities Accordingly pre pared specimens were fixtured in an Instron testing machine where loads between 118 and 1472 newtons were sequentially applied to the patella These experiments demonstrated that a small but significant increase in measured areas results from the higher loads applied to the patella along the F_{pf} vector line A similar series of experiments determined that the time period of loading caused no significant differ ences in measured areas over a 6 second to 2 minute span Subsequent specimens were loaded to 893 newtons at various knee flexion angles for 6 seconds Total patellar articular areas were determined by the same technique

RESULTS

The average and range for total patello-femoral contact areas at all measured knee flexion angles are presented in Figure 5 A The percentage of the average total patellar articular surface in contact with the femur is recorded The influence

this articulation during normal activities This study was initiated to define these quantities which may be useful in the development and pre-clinical testing of prostheses designed to treat this articulation

MATERIALS AND METHODS

Quantification of patello femoral contact stresses depends upon the force normal to the touching articular surfaces and upon the area of contact itself Fifteen fresh grossly normal cadaver lower limbs were minimally dissected Metallic markers were placed at the centers of the insertions of the patellar tendon on the tibia and patella, at the center of the insertion of the quadriceps mechanism on the superior pole of the patella and at the center of the quadriceps musculotendinous junction approximately 6 cm above the patella The extensor mechanism was manually pre tensioned and lateral roentgenograms made at 15 degree increments from full extension to full flexion

The knee joint angle, α was determined by drawing lines along the central axes of the tibia and femur (Figure 1A) Lines connecting the two metallic markers in the patellar tendon and in the quadriceps aponeurosis respectively defined an angle β (Figure 1B) the patellar

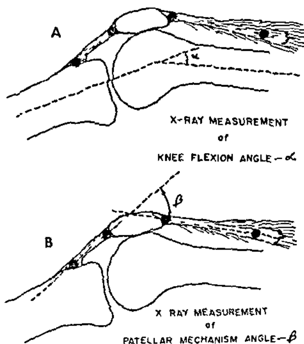


Figure 1 Radiographic method of determination of knee flexion angle α and patellar mechanism angle β

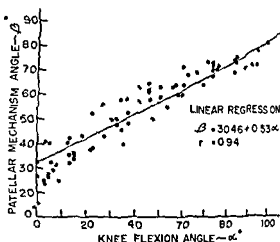


Figure 2 The relationship between the knee flexion angle and the patellar mechanism angle

mechanism angle The relationship between α and β (Figure 2) was plotted and subjected to exponential, power series and linear regression analysis The latter provided the best data fit and this relationship was used in the remainder of the study

If quadriceps force F_Q is assumed to be sustained equally by the quadriceps aponeurosis patella and the patellar tendon, and if the patellar mechanism angle β, is known the normal patellar contact force, the force of the patella against the distal femur F_{pf} may be calculated to the equation $F_{pf} = 2F_Q \sin \beta/2$ (Figure 3)

Morrison (1970 a and b) has reported maximum quadriceps forces and associated knee flexion angles for five activities—level walking

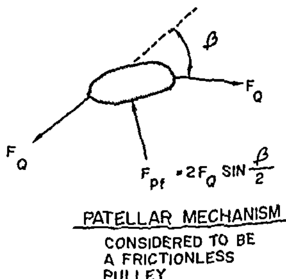
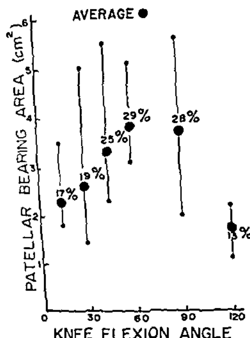


Figure 3 Method of calculation of patello femoral force



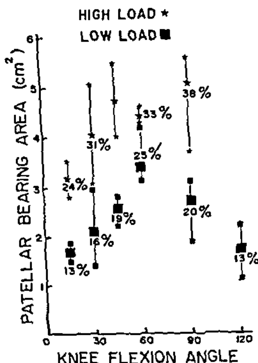


Figure 5. A. The averages and ranges of experimentally determined contact areas from all specimens at all knee flexion angles. B. The experimentally determined effect of the patello femoral loading conditions.

of low and high patello femoral loading conditions is presented in Figure 5 B.

An overall summary of our experimental data and contact stress calculations is presented in Table 1. Quadriceps forces are from the reports of Morrison (1907 a and b) and Smidt (1973). The tibial femoral contact areas are from the report of Kettelkamp & Jacobs (1972). The patello-femoral forces were calculated from the equation $F_p = 2F_q \sin \beta/2$ where F_p is the patello femoral force, F_q is the quadriceps force and β is the patellar mechanism angle determined as previously described. Patello femoral contact areas as measured are reported here as well as the averages of those measured under low load experiments, high load experiments and the overall average for all experiments. Patello femoral contact stresses were calculated from data by the equation contact stress

$$= \frac{\text{force moment to surface}}{\text{surface area}}$$

and are presented as they were influenced by the above loading conditions.

DISCUSSION

Our experimental results and calculations from available data indicate that patello-femoral *forces* are generally less than tibial femoral forces (*Morrison* 1970 a, b) during normal activities and during maximum *isometric quadriceps* contracture (Smidt 1973). We observed that the patella rarely touches the artic

Table 1 Patello femoral and tibial femoral contact forces areas and stresses compared

Quadriceps force data from	Activity	Knee joint angle (degrees)	Patellar mechanism angle (degrees)	Quadriceps force (Newtons)	Tibial femoral contact force (Newtons)	Tibial femoral contact areas (millimeters²)	Tibial femoral contact stress (N/mm²)
Morrison (1970 a 1970 b)	Walking	15	38	647	2109	660	3.2
	Up ramp	30	46	785	2786	560	5.0
	Down ramp	15	38	1923	2786	660	4.2
	Upstairs	45	54	1923	2963	560	5.3
	Downstairs	60	62	1687	2068	560	4.8
Smidt (1973)	Isometric	5	33	1393	1294	–	–
	Quadriceps	15	38	1776	1648	660	1.9
	Contracture	30	46	2168	2040	560	3.6
		45	54	2433	2325	560	4.1
		60	62	2530	2462	560	4.4
		90	78	2717	2698	560	4.8

Quadriceps force data from	Activity	Knee joint angle (degrees)	Patellar mechanism angle (degrees)	Quadriceps force (Newtons)	Patello femoral contact force (Newtons)	Patello femoral contact areas (millimeters²)			Patello femoral contact stress (N/mm²)		
						Low load	Average	High load	Low load	Average	High load
Morrison 1970 a 1970 b)	Walking	15	38	647	422	170	230	320	1.3	1.9	2.5
	Up ramp	30	46	785	618	210	260	410	1.5	2.5	2.8
	Down ramp	15	38	1923	1265	170	230	320	3.9	5.5	7.4
	Upstairs	45	54	1923	1756	260	330	480	3.7	5.3	6.9
	Downstairs	60	62	1687	1746	340	380	440	4.0	4.5	5.2
Smidt (1973)	Isometric	5	33	1393	795	–	–	–	–		–
	Quadriceps	15	38	1776	1158	170	230	320	3.6	5.0	6.8
	Contracture	30	46	2168	1697	210	260	410	4.2	6.6	8.0
		45	54	2433	2207	260	330	480	4.6	6.7	8.7
		60	62	2530	2609	340	380	440	6.0	6.8	7.8
		90	78	2717	3424	270	370	510	6.8	9.4	12.6

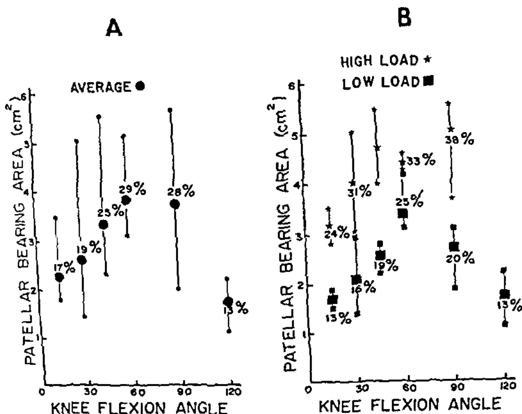


Figure 5 A The averages and ranges of experimentally determined contact areas from all specimens at all knee flexion angles B The experimentally determined effect of the patello femoral loading conditions

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$$= \frac{\text{force moment to surface}}{\text{surface area}}$$

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DISCUSSION

Our experimental results and calculations from available data indicate that patello-femoral *forces are generally less* than tibial femoral forces (Morrison 1970 a b) during normal activities and during maximum isometric quadriceps contracture (Smidt 1973) We observed that the patella rarely touches the artic

ular surface of the femur at full knee extension Patello-femoral contact *areas were less than total tibial-femoral* contact areas for all degrees of knee flexion under all *loading* conditions (Kettelkamp & Jacobs 1972) It is of interest that our values for patello-femoral contact areas are in generally good agreement with those reported by Aglietti et al (1975) using a casting technique employing the injection of acrylic cement into the joint with simulated quadriceps forces from zero to 5400 newtons

Bearing surface contact stress is of great importance in prosthetic joint design These studies indicate that the patello-femoral contact stresses are similar to those of the tibial-femoral joint during normal activities Under all loading conditions, and for all knee flexion angles, patello-femoral stresses were considerably greater than tibial-femoral stresses during isometric quadriceps contracture A recent report by Walker & Erkman (1975) proposes a load bearing role for the menisci with a total stressed area of up to 12 cm^2 observed in normal knees If a load bearing function of the menisci is confirmed, then the patello-femoral contact stresses would be proportionately much greater than tibial-femoral stresses

A prosthesis to treat the patello-femoral as well as the tibial femoral articulations of the knee must necessarily be designed to function under these anatomically imposed high stress conditions

High patello-femoral load values, small patello-femoral bearing surfaces and the resultant high stress magnitudes indicate the need for caution in the design and development of a patello femoral component for a total knee joint replacement prosthesis

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OSTEOCHONDRITIS DISSECANS OF THE KNEE

A Case Report of an Unusual Lesion on the Lateral Femoral Condyle

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A case of osteochondritis dissecans of the knee is described in which the site of the lesion on the supero medial aspect of the lateral femoral condyle is unique This case supports the theory that direct recurrent minor trauma causes osteochondral fractures which remain ununited producing the characteristic lesion

Key words osteochondritis dissecans lateral condyle of femur

Accepted 24 x 77

Osteochondritis dissecans is found most commonly in the knee and the classical site lies on the medial femoral condyle However a small percentage of lesions are found either on the infero-central or anterior aspects of the lateral femoral condyle (Green 1966 Aichroth 1971, Scott & Stevenson 1971 Lindholm 1974 Lindholm & Pylkkanen 1974) A lesion on the supero-medial aspect of the lateral femoral condyle has not been described before in the literature

CASE REPORT

A 17 year old male sustained a twisting injury to his right knee while playing tennis The knee was painful on the lateral aspect and some hours later began to swell Symptoms and signs subsided over the next few days One month later while playing football he had a similar episode One month after that, while playing hockey the knee became swollen and painful however the swelling did not subside and for a number of days the knee was locked He presented at the out patient department 6 months after these episodes with a history of repeated locking and swelling in his right knee Examination revealed tenderness over the lateral femoral condyle and a moderate effusion Quadriceps wasting amounted to 3 cm all other tests including the patellar apprehension test were negative X rays revealed osteochondritis of the lateral femoral condyle with at least one loose body (Figures 1 and 2)

Exploration of the knee was carried out soon afterwards and the osteochondritis dissecans was found to be in a most unusual site (Figure 3) There was a large loose fragment in a crater on the supero medial aspect of the lateral femoral condyle Three smaller loose bodies were recovered from different parts of the joint space The large fragment and crater were prepared and the fragment fixed in position with two Smillie pins (Figure 4) The patient made an uneventful recovery

DISCUSSION

Sir James Paget (1870) was the first to describe this lesion as a 'quiet necrosis' Konig (1888) was the first to call it osteochondritis dissecans and both men thought the lesion was the end result of trauma Many theories have been discussed since that time An ischaemic theory was advocated by Reiger (1920), Axhausen (1922) and Watson Jones (1952) However, the demonstration of a rich anastomotic blood supply in the femoral condyles by Rogers & Gladstone (1950) made a vascular lesion secondary

ular surface of the femur at full knee extension Patello-femoral contact *areas* were less than total tibial-femoral contact areas for all degrees of knee flexion under all loading conditions (Kettelkamp & Jacobs 1972) It is of interest that our values for patello-femoral contact areas are in generally good agreement with those reported by Aglietti et al (1975) using a casting technique employing the injection of acrylic cement into the joint with simulated quadriceps forces from zero to 5400 newtons

Bearing surface contact stress is of great importance in prosthetic joint design These studies indicate that the patello-femoral contact stresses are similar to those of the tibial-femoral joint during normal activities Under all loading conditions, and for all knee flexion angles, patello-femoral stresses were considerably greater than tibial-femoral stresses during isometric quadriceps contracture A recent report by Walker & Erkman (1975) proposes a load bearing role for the menisci with a total stressed area of up to 12 cm^2 observed in normal knees If a load bearing function of the menisci is confirmed, then the patello femoral contact stresses would be proportionately much greater than tibial-femoral stresses

A prosthesis to treat the patello-femoral as well as the tibial femoral articulations of the knee must necessarily be designed to function under these anatomically imposed high stress conditions

High patello-femoral load values, small patello-femoral bearing surfaces, and the resultant high stress magnitudes indicate the need for caution in the design and development of a patello femoral component for a total knee joint replacement prosthesis

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Figure 4 X ray of knee postoperatively showing the fragment reduced and held with Smillie pins

O'Donoghue (1966) stressed that patellar trauma only produced acute osteochondral fractures

This case would suggest that the lesion in this very unusual site could have been caused by recurrent minor trauma by the patella on the lateral femoral condyle If the patello femoral joint had been unstable then one would have expected a lesion on the lateral aspect of the condyle This medial lesion was caused by repeated minor trauma causing repeated osteochondral fractures which remain ununited producing the characteristic histology of reparation and repair described by Chiroff & Cooke (1975)

ACKNOWLEDGMENT

I am indebted to Mr J H Lowry FRCS for allowing me to report this case and to Professor Ian Smillie for his interest and advice

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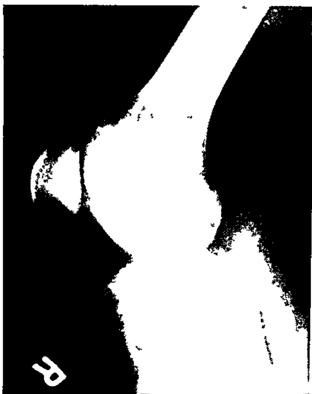


Figure 1 X-ray of the knee showing osteochondritis dissecans of the lateral femoral condyle and a loose body in the suprapatellar pouch



Figure 3 Photograph of lateral condyle showing the area of osteochondritis dissecans in a most unusual site and two loose bodies in the supra patellar pouch



Figure 2 Sky line X ray which shows osteochondritis dissecans on the lateral condyle

to embolic phenomena unlikely Trauma due to impingement of the tibial spine on the femoral condyles was suggested as the cause of the lesion by Fairbank (1933) and Smillie (1960) In an excellant review Green (1966) clearly defined the difference between acute osteochondral fracture and osteochondritis dissecans Recurrent minor trauma can cause stress fatigue in the subchondral bone and produce the features of osteochondritis dissecans Langenskiold (1955) produced such lesions in dogs and his work was later confirmed by Tallqvist (1962) and Aichroth (1971)

Green (1966) suggested that lesions on the lateral femoral condyle were due to trauma caused by the patella but

Table 1 Findings at operation graded according to Collins 0 = no cartilage destruction

Type of cruciate ligament rupture	Duration of condition	Collins' grade 0	I	II	III	IV	Total no of patients
Anterior cruciate	½ to < 2 years	13	6	2			21
	2 to 3 years	4	5	2	1		12
	> 3 years	3		6	1		10
Posterior cruciate	1 and 5½ years	1		1			2
Both	2 17 and 21 years					3	3
No of patients		21	11	11	2	3	48

three cases of meniscectomy, four explorations and one tibial osteotomy plus debridement of the joint

Methods During the operation a description was made of the injury to the ligaments and menisci and the state of the articular cartilage and the presence of osteophytes was noted Ahlback (1968) recommended radiography of the knee joint during weight bearing in order to disclose narrowing of the articular space That this examination is lacking in most of the cases is irrelevant as the pathoanatomy of the cartilage was examined directly during surgery On the basis of this description the cartilage destruction was graded according to Collins (1949)

Grade I superficial destruction of cartilage tangential flaking early fibrillation and small blisters or grooves No marginal hyperplasia of bone or cartilage

Grade II more extensive cartilage destruction but still confined to pressure and movement areas and without denudation of bone Deep fibrillation and marked loss of cartilage substance Early marginal hyperplasia

Grade III denudation and usually eburnation of bone in one or more pressure areas though regions of unaffected cartilage often remain Obvious osteophytes at joint margins

Grade IV complete loss of cartilage from large areas of the joint surface Eburnation of exposed bone epiarticular osteophytes remodelling of the contour of the bone ends

Conventional a p and lateral radiographs were studied for osteophytosis Felsenreich s sign i e deformity of the tubercles of the intercondylar eminence (Felsenreich 1934) and structural changes i e bone cysts and sclerosis The healthy knee was used as a control

In order to use both the radiographical and operative findings as a combined measure of development of osteoarthrosis the suggestions of Hulth (1969) have been followed As Collins grade I and II are clinically silent and osteophytes without other X-ray changes are not sufficient to allow a firm diagnosis of osteoarthrosis (Hulth 1969 Danielsson & Hernborg 1970), these groups have been given a different designation on the diagram in Figure 1 Collins' grade III and IV and radiographical findings of structural bone changes, varus deformity or joint space narrowing (as defined by Ahlback) have been used as sufficient criteria to allow a firm diagnosis of significant arthrosis (black columns in Figure 1)

The findings were correlated with the duration of knee instability and with the patient's age at onset of symptoms In addition, earlier meniscectomy was taken into consideration as this could influence development of osteoarthrosis (Johnson et al 1974)

FINDINGS

The patients were grouped as shown in Table 1 43 patients with rupture of the anterior cruciate ligament (group 1), two patients with rupture of the posterior cruciate ligament (group 2) and three patients lacking both anterior and posterior ligaments (group 3) It appears from Table 1 that undamaged cartilage became less frequent as the duration of symptoms increased, so it can be assumed that cartilage destruction is a progressing phenomenon in these knees If only one of the cruciate ligaments is lacking, the process is relatively slow, if both are lacking the process is quick and pronounced—all knees in group 3 belong to grade IV

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OSTEOARTHROSIS FOLLOWING INSUFFICIENCY OF THE CRUCIATE LIGAMENTS IN MAN

A Clinical Study

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Based on a series of 48 patients with old untreated ruptures of one both cruciate ligaments the development of osteoarthrotic changes w demonstrated by radiography and at operation The changes we similar to those seen in animal experiments and developed in the sam sequence Osteophytes occurred in knees with anterior cruciate in sufficiency after about 2 years, significant osteoarthrotic change occurred after longer periods and particularly in knees with damag to both cruciate ligaments

Key words cruciate ligaments gonarthrosis, knee osteoarthrosis

Accepted 12 x 77

A matter of current interest to the orthopaedic surgeon is to what degree an untreated rupture of the anterior and/or posterior cruciate ligaments may cause osteoarthrotic changes in the knee joint of man Section of the cruciate ligaments in experimental animals causes structural changes in the joint cartilage and bone (Magnuson 1941, Hulth et al 1970, Marshall & Olsson 1971, Bohr 1976) but because the gait and weight bearing as well as the physical activity in general, and the speed of physiological aging processes, are so different in the joints of animals and man a clinical study of the processes in man may help to elucidate this problem

PATIENTS AND METHODS

Definition The term osteoarthrosis is used here to describe a condition in which aseptic destruction of the articular cartilage leads to denudation of the subchondral bone with subsequent structural changes in the form of cysts and sclerosis To the clinician the essential symptom is pain To the pathologist destruction of cartilage is a necessary finding (Collins 1949) while to the radiologist the condition is linked first and foremost with narrowing of the joint space and also with the above mentioned structural changes in the subchondral bone (Ahlback 1968) The presence of osteophytes alone cannot be taken as a significant sign of osteoarthrosis (Danielsson & Hernborg 1970)

Patients All the patients included in the present study were operated on by the author during the years 1972 to 1975 The criterion for inclusion was rupture of one or both cruciate ligaments with symptoms lasting for more than 6 months The series comprises 48 patients of whom only seven are females Thirty six patients were below the age of 30 at the time of operation and 44 patients below the age of 40, the mean age was 28 ranging from 16 to 73 There were no bilateral cases The type of surgical repair included 33 cases of the Jones procedure for replacement of the anterior cruciate ligament seven other kinds of ligament plasty

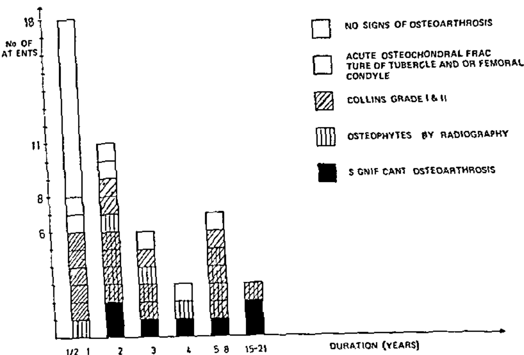


Figure 1 Duration of insufficiency of cruciate l gaments related to osteoarthrosis in 48 patients S gn ficant arthrosis means that the knee was class fied as Coll ns grade III or IV and/or showed structural changes such as cysts or bone sclerosis varus deformity or joint space narrowing at ra l ography The uninjured knee was normal

literature is included in Figure 1 At operation an acute osteochondral fracture of the medial tubercle was found in four knees with an associated osteochondral fracture of the latero-distal aspect of the medial femoral condyle in two knees Presumably these small fractures are sustained by compression or cutting when the two surfaces mentioned contact each other during a sudden subluxation in the unstable knee

In the three patients with rupture of both the anterior and posterior cruciate ligament and one of the collateral ligaments (group 3) osteophytes structural bone changes and narrow joint space were shown at radiographs At operation large osteophytes together with widespread denudation of bone were found In one of these patients the changes developed in the course of 2 years (Figure 2) in another after 17 years The third patient was a woman of 73 years with an osteoarthrotic varus deformity caused by 21 years of knee instability The deformity was corrected by an osteotomy Her other knee was completely normal (Figure 3)

DISCUSSION

Danielsson & Hernborg (1970) have shown that knee joints with osteophytes in the tibiofemoral joint do not necessarily develop structural changes They do not mention drawer sign or collateral looseness so one must expect that such patients were excluded from their study

In studies on dogs after transection of the anterior cruciate ligament in one knee Marshall (1969) and Marshall & Olsson (1971) found rapid osteophyte

Table 2 Radiographical findings Number of patients with unilateral abnormal findings

Type of cruciate ligament rupture	Duration of condition	No radiographic abnormalities	Osteophytes	Structural bone changes (cysts sclerosis) and/or narrowing of joint space	Total no of patients
Anterior cruciate	½ to < 2 years	19	2		21
	2 to 3 years	5	7	1	12
	> 3 years	2	8	2	10
Posterior cruciate	1 and 5½ years	2	0	0	2
Both	2, 17 and 21 years	0	3	3	3
No of patients		28	20	6	48

Table 3 Grade of osteoarthrosis according to Collins related to patients age at injury to cruciate ligaments 0 = no cartilage destruction

Age (years)	No of patients	Patients divided according to Collins' grade of osteoarthrosis				
		0	Grade I	Grade II	Grade III	Grade IV
< 20	12	6 (50 %)	3 (25 %)	3 (25 %)	0	0
20–30	30	14 (47 %)	6 (20 %)	8 (27 %)	2	0
31–40	3	0	2	0	0	1
> 40	3	1	0	0	0	2
Total	48	21	11	11	2	3

Among the 16 patients in group 1 with cartilage wear of grade I–III and up to 3 years since onset of the condition, meniscal damage, or previous meniscectomy, was found in eight, or half of them In those with duration longer than 3 years, 7 out of 10 had meniscus injury or an earlier removed meniscus in combination with anterior cruciate ligament insufficiency Five of these had cartilage wear grade II–III, two had none at all Of the three patients with intact menisci, two had grade II cartilage wear and one had none In group 3 all had osteoarthrosis grade IV—one of them with intact menisci The importance of this will be discussed

In Table 2 the radiographical findings are shown, the same grouping of the patients being used The radiographical signs progress at a somewhat slower rate but in full accordance with the pathoanatomical changes

Table 3 shows the grade of osteoarthrosis related to the age at injury No conclusions can be drawn from this, as nearly all the patients were below 30 at the onset of symptoms and the very few older patients (6) include the three with rupture of both cruciate ligaments and, in addition the collateral ligaments and among these are two with very long lasting symptoms They have all odds against them and have all developed a grade IV arthrosis

A summary of the essential results is presented in Figure 1 This bar chart illustrates the increase in incidence and severity of osteoarthrosis as the interval from the time of the original injury increases

A finding not earlier described in the

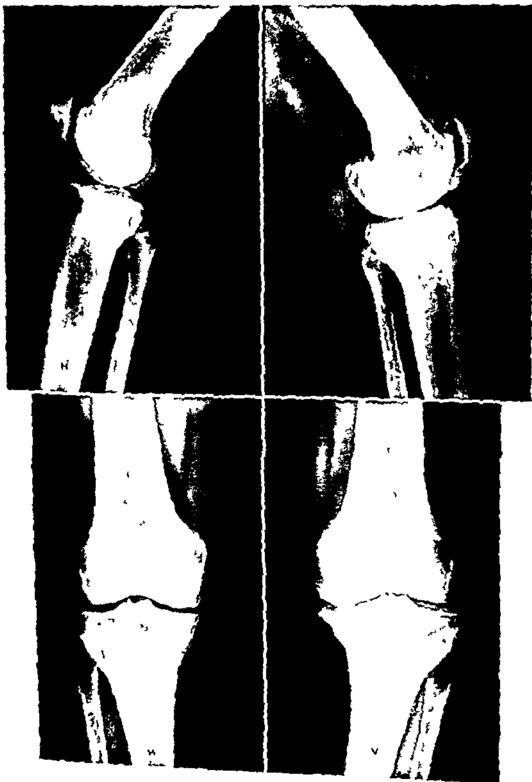

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Figure 2 Photograph from the operation of a 49 year old man with total rupture of both crucia ligaments and the medial collateral ligament Duration of knee instability only 2 years No destruction of articular cartilage which was found on all the articular surfaces of the joint Her only the medial femoral condyle is visible Note also the marked thickening of synovial membran and fibrous joint capsule

formation in the unstable knee, but no subchondral structural changes (cysts or bone sclerosis), even after longer observation periods They conclude, as do Danielsson & Hernborg, that osteophytes are not necessarily a sign of degenerative lesions in the cartilage, and that the diagnosis of osteoarthrosis should not be made solely on the presence of osteophytes

From the results of these investigations it is not known whether the changes caused by unstable knees in the dog—and in man— are of a proliferative type only or if they are a precursor to, and may develop into, a significant osteoarthrosis

That many patients with unstable knees over the years develop an advanced osteoarthrosis has been stressed by Liljedahl et al (1965) This is in accordance with Collins' (1949) suggestion that the initial lesion of osteoarthrosis is destruction of articular cartilage Such destruction seems apt to develop as a consequence of repeated major and minor traumas caused by the numerous sub luxations in unstable knees Recently

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Figure 3 Lateral and antero posterior radiographs of a 73 year old woman with an unstable left knee (I) The condition had been present for 21 years At operation total atrophy of both cruciate ligaments and valgus instability was found The right knee (II) was normal Left knee with osteophytosis and bone sclerosis also in the femoro patellar joint Loosened cartilage pieces have formed free bodies Left femoro tibial joint with almost completely obliterated joint space bone sclerosis and compression causing varus deformity

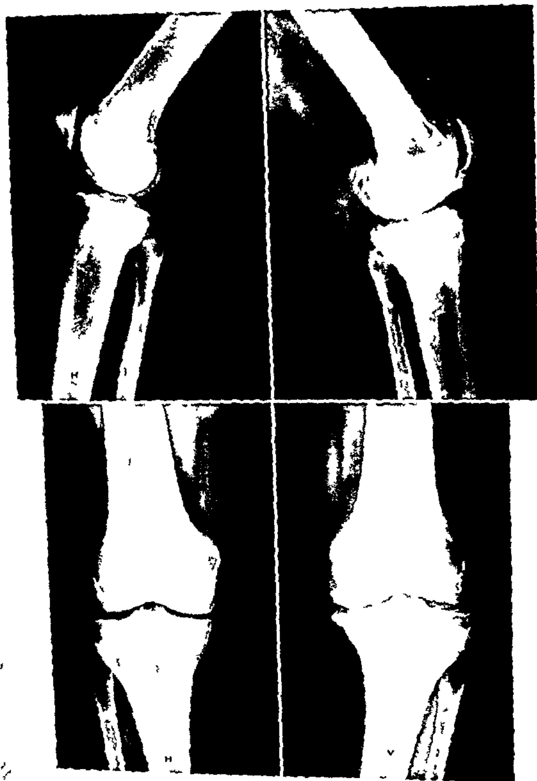

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V



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THE HALLUX AND RHEUMATOID ARTHRITIS

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The purpose of this report is to consider involvement of the great toe by rheumatoid arthritis defining significant deformities describing clinical patterns and discussing the pathomechanics of these findings in what is an ongoing disease 200 consecutive patients admitted to hospital with classical or definite rheumatoid arthritis were screened for pain or deformity of the great toe Feet that had undergone previous surgery or had other underlying pathology were excluded from the series 194 feet were found to have halluceal involvement. Although hallux valgus was the commonest deformity it was found in combination with other significant deformities in many cases Hallux rigidus was an important lesion in this series as was interphalangeal hyperextension Other important lesions encountered were metatarsus primus varus and medial rotation of the toe their relationship to hallux valgus is discussed

Key words hallux valgus hallux rigidus, rheumatoid arthritis

Accepted 14 xi 77

Foot disability in rheumatoid arthritis is common (Vainio 1956 Vidigal et al 1975), and frequently involves the hallux early in the disease Indeed symptoms in the first metatarso-phalangeal joint may precipitate local surgical intervention before the disorder's general nature is evident This may result in complaints by the patient that surgery caused the arthritis, aggravated foot problems or contributed nothing towards their relief This prompted an analysis of the significant halluceal deformities in a group of hospital patients with established rheumatoid arthritis This paper does not discuss the treatment of individual conditions of the great toe because every patient requires a different programme of management The joints of the foot, knee and hip can dictate what sort of operation or conservative measure is necessary, not to mention the general medical state of the patient, so that any didactic statements about therapy would be misleading

PATIENTS AND METHODS

Consecutive admissions to the rheumatology and orthopaedic wards were assessed for foot pain and deformity in the presence of "classical" or definite rheumatoid arthritis (Ropes et al 1959) Out of 200 patients affected with the disease for more than a year (mean 12 9 years) significant findings involving the [illegible]
foot or [illegible]
Asses[illegible]
er et al [illegible]

Bohr (1976) produced experimental osteoarthrosis in the rabbit knee joint by section of both cruciate ligaments and removal of the medial meniscus using the method of Hulth et al (1970) Within 10 months these animals developed changes in the joint cartilage and subchondral bone of the same severity as those found in advanced osteoarthrosis in man

The findings in the present series are in good agreement with the experimental results mentioned above If only one of the cruciate ligaments is ruptured many years may pass before significant osteoarthrotic changes develop even though progressive destruction of cartilage does occur over the years In severe clinical injuries, however, with rupture of both cruciate ligaments—comparable to the experimental injuries produced in rabbits by Bohr (1976)—advanced osteoarthrotic changes do develop in a relatively short time

The question of how a meniscus injury or meniscectomy may influence this course was investigated by Johnson et al (1974) They suggested that meniscectomy could cause osteoarthrosis over a period of many years Unfortunately his material was not specific as cases of associated cruciate ligament rupture were fairly frequent This is due to the fact that these injuries very often are combined as they were in the series presented above In the present series, however, 10 patients with cartilage destruction of grade I to III and one patient of grade IV had intact menisci, which suggests that the menisceal factor is not essential, although it may be a contributory factor This is also the opinion of Johnson et al (1974)

It may be concluded that osteophytes and pathoanatomical lesions of Collins' grade I and II are likely to develop within about 2 years in knees with anterior cruciate ligament rupture Significant arthrosis can develop after longer periods, especially in cases of rupture of both cruciate ligaments with gross instability An additional meniscus lesion or removed meniscus may accelerate the process

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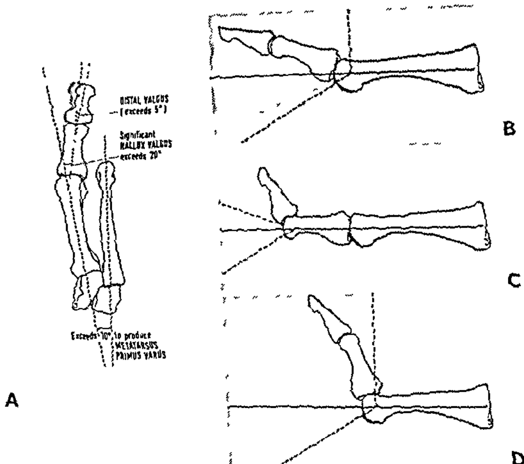


Figure 1 A Diagram to show the angular relationships measured on weight bearing radiographs of the foot
B Hallux rigidus—limited arc movement at the metatarso-phalangeal joint. The maximum dorsiflexion as defined is 20° (unshaded arc) whereas the normal range is shown by the interrupted line
C Chisel toe—the distal phalanx maintains an extended posture having an arc of dorsiflexion beyond 20° (interrupted line) at the interphalangeal joint
D Hallux elevatus—absent range of plantar flexion at the metatarso-phalangeal joint

Table 1 Summary of the 266 deformities that were found in 193 feet

Deformity	Bilateral	Unilateral	Total feet	Percentage of all the feet at risk
Hallux valgus	42	30	114	59
Hallux rigidus	24	7	55	28
Chisel toe	12	19	43	22
Hallux elevatus	6	8	20	11
Interphalangeal claw	3	7	13	7
Interphalangeal valgus	4	5	13	7
Interphalangeal fusion	1	2	4	2
Metatarsophalangeal dislocation	1	1	3	< 2
Hallux varus	0	1	1	< 1
No measured deformity	7	16	30	15

tory or neurological deficit, the presence of swelling, callosities bursae, sinuses, nail changes and the state of footwear were made With the patient supine and knee extended, angular relationships between the first metatarsal bone and phalanges were measured with a goniometer, similarly passive movements of the joints were estimated Ideally observations should be made *standing on a firm surface*, in practice this is difficult and the supine examination was a compromise In this position active movement cannot achieve the functional range possible when erect, thus passive estimations were necessary for example, the normal hallux dorsiflexes to 90° or more when the phalanges are subjected to body-weight, yet supine active contraction may achieve only 60° or less

Radiographs and photos of the standing forefoot display halluceal deformities most clearly and are essential for measuring metatarsus primus varus accurately Patients with valgus or varus hindfeet, or those who were unable to stand barefoot could not be recorded in this way The relationship of the first metatarsal the sesamoids and the remaining metatarsal heads was demonstrated in tangential partial weight bearing radiographs (Dixon & Gheith 1973)

DEFORMITIES

The major deformities, as defined below, were hallux valgus (Figure 1a), hallux rigidus (Figure 1b), and "Chisel-toe" (Figure 1c) Less common and less disabling deformities were hallux elevatus (Figure 1d), interphalangeal claw toe, interphalangeal valgus (Figure 1a), interphalangeal fusion, hallux varus, and metatarso-phalangeal dislocation (Table 1)

Of 104 patients examined, four had undergone bilateral and four unilateral surgery of the hallux Rejection of these, and a further foot subjected to ankle fusion and one *affected by poliomyelitis* left 100 patients with 194 feet for analysis Bilateral *deformity* was recorded in 70 patients and unilateral deformity in 23 If one recalls the 12 feet excluded by previous surgery, we conclude that over 50 per cent of patients with rheumatoid arthritis may suffer from foot disability and of these approximately 90 per cent will manifest significant great toe deformity in one or both feet

Hallux valgus

Deformity was considered *significant* when the proximal phalanx deviated laterally on the metatarsal at least 21° as measured by standing radiographs or photographs (Figure 1a), and involved 114 feet of which 99 exhibited a 'bunion as indicated by skin pressure signs of reddening and thickening bursal formation with underlying bony hypertrophy characteristic of non-rheumatoid hallux valgus was unusual Six feet with hallux valgus of 20° or less also displayed 'bunion" formation whilst 15 feet with hallux valgus between 21° and 50° did not, being patients who walked little, wore soft slippers or individually cast seamless shoes This would suggest that bunion formation is a function of tight footwear rather than the extent of deviation Four feet with mild to moderate hallux valgus (15°, 19°, 25° and 38°) exhibited septic "bunions" with sinuses *suggesting* that patients with more severe deviation had learned how to select more suitable footwear

Radiographic evidence of erosions and irregularity of the first metatarso phalangeal joint were noted in 98 (86 per cent) of the 114 feet with hallux valgus (Table 2) of the toes without X ray change, valgus varied from 25° to 63°

Metatarsus primus varus

Divergence between the long axes of the first and second metatarsal of 10° or more (Figure 1a) is a well recognised association with *hallux valgus* of non-rheumatoid origin and we confirmed a similar association in rheumatoid patients with angles between 10° and 25° in 89 out of 100 feet with suitable radiographs Significant metatarsus primus varus was observed in a few feet with hallux valgus of less than 20° but increasing severity of valgus was generally correlated with increasing metatarsal deviation (Figure 2) Of 47 toes with valgus exceeding 40°,

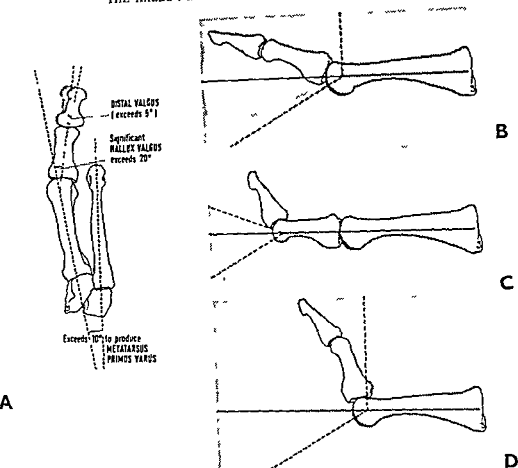


Figure 1 A Diagram to show the angular relationships measured on weight-bearing radiographs of the foot

B Hallux rigidus—limited arc movement at the metatarso-phalangeal joint The maximum dorsiflexion as defined is 20° (unshaded arc) whereas the normal range is shown by the interrupted line

C Chisel toe—the distal phalanx maintains an extended posture having an arc of dorsiflexion beyond 20° (interrupted line) at the interphalangeal joint

D Hallux elevatus—absent range of plantar flexion at the metatarso-phalangeal joint

Table 1 Summary of the 266 deformities that were found in 194 feet

Deformity	Bilateral	Unilateral	Total feet	Percentage of all the feet at risk
Hallux valgus	42	30	114	59
Hallux rigidus	24	7	55	28
Chisel toe	12	19	43	22
Hallux elevatus	6	8	20	11
Interphalangeal claw	3	7	13	7
Interphalangeal valgus	4	5	13	7
Interphalangeal fusion	1	2	4	2
Metatarsophalangeal dislocation	1	1	3	<2
Hallux varus	0	1	1	<1
No measured deformity	7	16	30	15

Table 2 Summary of the radiological findings in 194 feet

Target Joint	Erosive changes on X-ray Present	Absent
Interphalangeal joint	57	137
Interphalangeal deformity	29	40
Chisel toe	20	23
Interphalangeal valgus	8	5
Interphalangeal claw	1	12
Interphalangeal fusion	4	0
No interphalangeal deformity	28	97
Metatarsophalangeal joint	145	49
Metatarsophalangeal deformity	126	27
Hallux valgus	98	16
Hallux rigidus	45	10
Hallux elevatus	17	3
Hallux varus	1	0
No metatarsophalangeal deform	19	22
First metatarso medial cuneiform joint	44	144
Hallux valgus	30	84
Metatarsus primus varus > 10°	30	70
Interphalangeal and metatarso phalangeal joints combined	42	15
First metatarso medial cuneiform joint and metatarso phalangeal joint combined	39	5
Interphalangeal metatarso phalangeal and first metatarso medial cuneiform joints combined	13	31
Ankle and/or tarsal changes	121	73

metatarsus primus varus was 10° or more in every case It is debatable whether metatarsal deviation initiates hallux valgus or is a compensatory sequel to subluxation of the proximal phalanx, nevertheless if the first metatarsal deviates excessively from the second then structural changes at their bases are inevitable In this series radiographic erosions sclerosis or fusions affecting the first metatarso-medial cuneiform joint, the interval between the first and second metatarsal bases or between medial and intermediate cuneiforms were observed (Table 2) in 44 feet and compared where possible with the angle of metatarsus primus varus The latter was significantly greater in those feet with radiographic disease of the metatarsal base than those without ($P < 0.01$), the mean angles of metatarsus primus varus being 15 5° and 12 7° respectively, denoting that basal disease if not the primary cause, at least contributes to the more severe degrees of metatarsal deviation and hence hallux valgus itself

Hallux tortus

Medial twisting or rotation of the phalanges about the first metatarsal long axis has received little attention although Hardy & Clapham (1951) recognised its

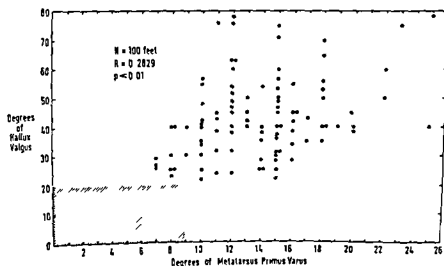


Figure 2 Graph showing the angle of hallux valgus plotted against the angle of metatarsus primus varus The correlation is significant ($P < 0.01$) N = Number of X rays R = Correlation coefficient



Figure 3 Hallux tortus Medial rotation of the hallux in the presence of valgus deformity

singular association with hallux valgus, however, they reported no accurate measurements to quantify the rotational displacement In our patients, standing photographs taken of the toes end on have been utilised to measure the angle made by the great-toe nail margin with respect to the plane of the floor (Figure 3), the nail normally being parallel to the floor This angle was estimated to the nearest 5° and angles of 20° and above taken to be significant although lesser degrees of rotation were uncommon without accompanying hallux valgus Hallux tortus of more than 20° was always associated with hallux valgus (Figure 4). Not all valgus toes were twisted but of 42 toes with more than 40° hallux valgus, 36 (86 per cent) were rotated from 20° to 65°, many of which developed a characteristic callosity medial to the interphalangeal

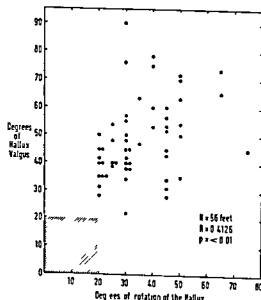


Figure 4 Graph showing the angle of hallux valgus plotted against the rotational angle of tortus There is a positive correlation which is significant ($P < 0.01$) N = Number of feet measured R = Correlation coefficient

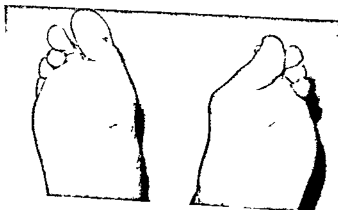


Figure 5 Hallux tortus Plantar callosities are present under the medial aspect of the inter phalangeal joint

joint (Figure 5) a source of complaint in addition to their "bunion". Significant rotation was bilateral in 23 patients In two the twist was reversed or lateral, one being a case of hallux varus and one of hallux elevatus Lateral tortus was also recorded in another case of hallux varus, a sequel to excision arthroplasty for hallux valgus

Hallux rigidus

Terminology with respect to mobility of the first metatarso-phalangeal joint is confusing for by definition rigidus implies complete fixity, nevertheless, this quality applies to those rheumatoid joints achieving bony fusion following severe and prolonged disease However, in current practice hallux rigidus encompasses mobile yet restricted joints (Mercer & Duthie 1964) with absence or reduction of dorsiflexion as the essential indicator of disability Bonney & Macnab (1952) emphasise that restriction of movement may not correlate with disability for this varies with age, sex, footwear, occupation, etc, and on interphalangeal joint mobility In rheumatoid arthritis, we would add, halluceal function is also related to tarsal and ankle joint disease, for restriction of hindfoot dorsiflexion stresses a damaged great-toe during walking, and such stress increases as metatarso-phalangeal mobility diminishes Vainio (1956) noted distal phalangeal hyperextension with associated callosities beneath the interphalangeal joint in rheumatoid patients when dorsiflexion of the proximal phalanx was 20° or less Our experience demonstrates this to be far from universal and shows callosities present in many feet for other reasons, we do, however, accept Vainio's definition of hallux rigidus as 20° or less of passive dorsiflexion of the proximal phalanx on the first metatarsal Vainio makes no comment on the plantar-flexion range and in noting general lack of attention to this Kessel & Bonney (1958), when discussing adolescent hallux rigidus, state that a good range of plantar-flexion was preserved in all their cases with an average of 50°; the average dorsiflexion being only 5° In our series, where dorsiflexion was 20° or less, a range of plantar-flexion was obtained in all but two cases such patients are considered to have hallux rigidus (mobile) in contradistinction to a smaller group of patients with truly rigid or fused joints termed hallux rigidus (immobile) This terminology may appear tendentious but as demonstrated below the two groups differ in several respects

Hallux rigidus (mobile) Forty-three feet of 30 patients came into this category, 26 feet displayed an accompanying hallux valgus, 28 feet showed radiological evidence of tarsal and/or ankle changes and 23 feet (53 per cent) developed hyperextension of the distal phalanx Some cases of hallux rigidus displayed minimal or no radiological evidence of erosions in the metatarso-phalangeal joint and some possibly developed restricted movement before the onset of rheumatoid arthritis Furthermore, some patients stated that their toes were stiff prior to and independent of the arthritis However, in long-standing severe rheumatoid arthritis there is little doubt that the disease itself precipitates the ultimate complication of spontaneous joint fusion

Hallux rigidus (immobile) The 12 feet in this group illustrate this latter statement for the mean duration of rheumatoid disease was 25 2 years against 12 1 years in the hallux rigidus (mobile) group In addition, every foot demonstrated not only tarsal but ankle changes including several spontaneous fusions of these joints These findings suggest that severe and prolonged disease were necessary preludes to metatarso-phalangeal joint fusion A position of hallux valgus was present in 7 of the 12 feet, a similar proportion to the mobile group Co existent distal hyperextension was present in five feet, again much as in the mobile

group and thus one concludes that rheumatoid hallux rigidus is compensated by distal phalangeal hyperextension in approximately half the cases, less than might be anticipated. In the non rheumatoid foot Fitzgerald (1969) has shown that after metatarso-phalangeal arthrodesis compensatory interphalangeal dorsiflexion does not occur and indeed mobility decreases as a sequel to the altered loading on the distal joint and intra articular degenerative changes were accelerated. Six feet showed evidence of erosions at the first metatarsal medial cuneiform joint.

Hallux flexus

Vainio (1956) considers this to be an extreme form of hallux rigidus where dorsiflexion is totally absent and the proximal phalanx is held plantar flexed. Weight is not taken by the metatarsal head and instead is transferred to the distal phalanx resulting in callosities on its plantar surface. In conventional foot wear, however, the major symptom of pain follows friction between the shoe 'upper' and the dorsum of the metatarsal head exposed by the flexed phalangeal attitude.

In this series no toes were classified as hallux flexus, perhaps an indicator of its infrequency, although elsewhere we have observed this deformity in rheumatoid feet (Figure 6).

Chisel toe

Interphalangeal hyperextension alone or in association with hallux rigidus can be itself a source of symptoms particularly when dorsal subluxation of the distal on the proximal phalanx ensues. The "chisel toe" syndrome (Dixon 1971) is characterised by callosity formation on the plantar aspect (Figure 7a) and a skin furrow on the dorsal aspect of the interphalangeal joint associated with changes at the free nail margin resulting from collision between it and the overlying shoe (Figure 7b). Increasing hyperexten-

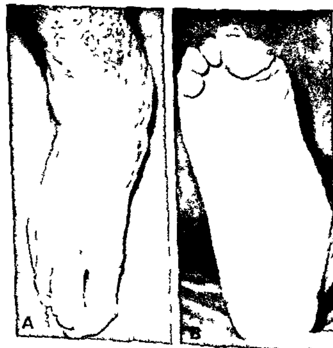


Figure 6 Hallux flexus

A Dorsal view showing callosity over the metatarso phalangeal joint

B Plantar view showing callosity under the pulp of the great toe

sion augments the probability of the nail cutting or chiselling through the shoe, hence the name in other cases the thickened nail may damage the pulp leading to infection (Figure 7c)

Excess joint hyperextension is defined as dorsiflexion of 20° or more of the distal phalanx (Figure 1c), which in this series was noted in 83 feet, of which 43, involving 31 patients, were considered to be "chisel toes"

As few as 20 out of 43 "chisel toes" were found to have radiographic changes in the interphalangeal joint, namely erosions and juxta-articular cyst formation (Table 2) thus some 53 per cent of "chisel toes" have dorsal subluxation of the distal phalanx without significant joint damage (Figure 7d) Likewise, 32 out of 40 toes with simple hyperextension deformity lacked associated bone changes, indicating that subluxation is frequently related to factors other than interphalangeal joint destruction

As has been suggested, hyperextension of the distal joint may compensate for hallux rigidus and indeed 14 "chisel toes" were so associated, however, this is only 25 per cent of the rigid halluces Surprisingly, we found an association with hallux elevatus, there being five "chisel toes" among 20 feet with elevatus Eight unilateral "chisel toes" displayed no demonstrable hyper-extension in the opposite toe whilst 20 were combined with hallux valgus (25° to 55°), somewhat fewer than expected and proportionately less than those associated with rigidus

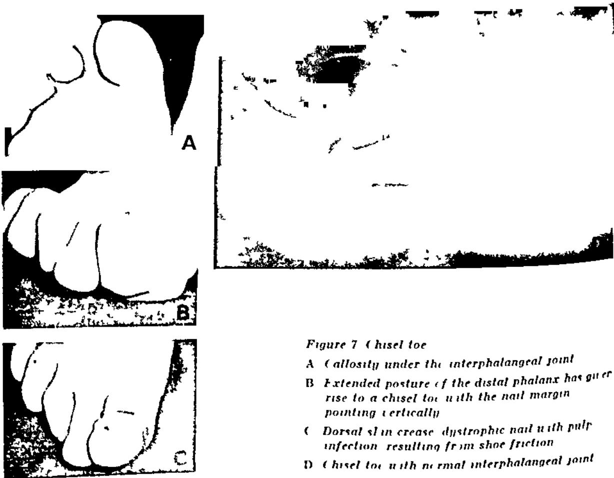


Figure 7 Chisel toe

A *Callosity under the interphalangeal joint*

B *Extended posture of the distal phalanx has given rise to a chisel toe with the nail margin pointing vertically*

C *Dorsal skin crease dystrophic nail with pulp infection resulting from shoe friction*

D *Chisel toe with normal interphalangeal joint*

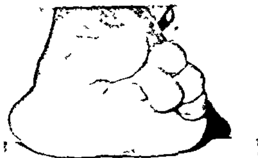






Figure 8 Hallux elevatus and valgus
A *Anterior view showing marked elevatus with packing of the lesser toes*
B *Dorsal view showing severe valgus*
C *Plantar view showing complete absence of the hallux from the plantar profile*

OTHER DEFORMITIES

Hallux elevatus

Elevatus is defined as inability to plantar-flex the proximal phalanx beyond neutral in the presence of dorsiflexion exceeding 20° (Figure 1d) In most instances dorsiflexion was 60°–90°, frequently the loss of plantar-flexion was severe with inability to achieve neutral by as much as 40° resulting in striking elevation of the proximal phalanx (Figure 8) As a consequence compensatory plantar-flexion of the distal phalanx might be expected with fixed interphalangeal clawing and dorsal callosity formation over the interphalangeal joint However, out of 20 feet with hallux elevatus, only two toes were clawed at the distal joint, by contrast 15 interphalangeal joints were hyperextensible beyond 20° Other co existent problems included 12 feet with ankle or tarsal joint damage and 11 feet with hallux valgus both these numbers were in proportion to the overall distribution By our definition hallux rigidus cannot co-exist with elevatus

Elevation of the proximal phalanx is said to compensate for depression of the metatarsal head which may be congenital or possibly in rheumatoid arthritis a sequel to bone destruction at the metatarsocuneiform level the five feet with erosions at the metatarsal base were insufficient to support this possible mechanism Radiologically rheumatoid damage of the metatarso-phalangeal joint was recorded in 18 (90 per cent) of these feet, the interphalangeal joint was similarly affected in only three (15 per cent)

Hallux elevatus rarely caused complaint of itself for associated and more symptomatic deformities were commonly present (Table 3)

sion augments the probability of the nail cutting or chiselling through the shoe, hence the name in other cases the thickened nail may damage the pulp leading to infection (Figure 7c)

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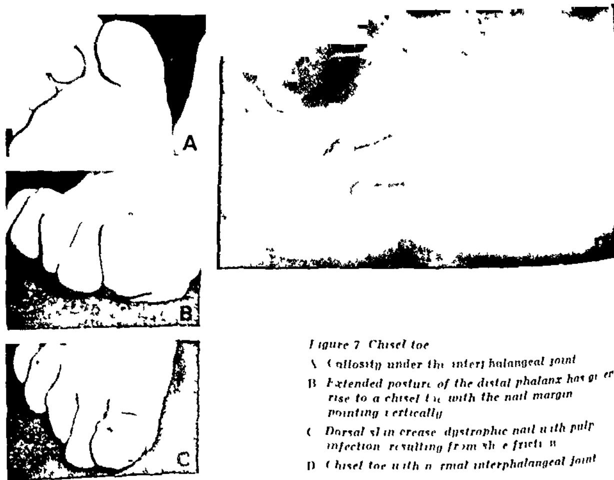


Figure 7 Chisel toe

A *Callosity under the interphalangeal joint*

B *Extended posture of the distal phalanx has given rise to a chisel toe with the nail margin pointing vertically*

C *Dorsal skin crease dystrophic nail with pulp infection resulting from shoe friction*

D *Chisel toe with normal interphalangeal joint*

the common dislocation of the lesser toes onto the dorsum of metatarsal heads or necks

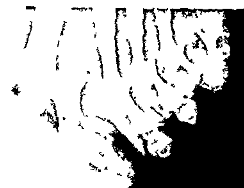


Figure 9 Metatarso phalangeal dislocation The sesamoid bones have maintained a normal anatomical relationship to the proximal phalanx

Hallux varus

Deviation of the proximal phalanx medially from the metatarsal mid line axis is relatively rare and even small degrees of varus are worthy of note Of the two cases with this deformity, one deviated 20° and the other a sequel to a Kellers arthroplasty, some 25° As observed under hallux tortus both were associated with lateral rotational changes of the order of 15° and 10°, respectively In the toe not subjected to surgery cystic change was well marked in the base of the proximal phalanx at its medial corner suggesting that the varus position was a protective response to relieve pressure opposite the cyst (Figure 10) Lateral phalangeal rotation with hallux varus is the reverse of medial rotation commonly accompanying hallux valgus

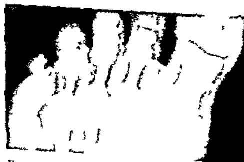


Figure 10 Hallux varus showing a cyst or geode near the medial edge of the metatarso phalangeal joint

COMBINED DEFORMITIES

Of 194 feet at risk, 31 displayed no significant halluceal deformity whilst the remaining 163 feet yielded a total of 266 deformities exclusive of metatarsus primus varus, hallux tortus, and interphalangeal hyperextension Thus many feet manifested two deformities and indeed three were demonstrated in 15 feet, the ubiquitous hallux valgus being present in all of this latter group (Table 4)

Hallux valgus was observed in 60 per cent of the total feet, being noted in a similar percentage of feet with rigidus and elevatus However, hallux valgus was seen in combination with only 47 per cent of chisel toes and most strikingly only 8 per cent of interphalangeal valgus By contrast hallux valgus complicated 92 per cent of interphalangeal claw toes (Table 5)

Hallux rigidus involved 28 per cent of the total feet and affected a similar percentage of valgus and "chisel toes" Only one case of rigidus was combined with interphalangeal clawing and none were

Table 4 Triple deformities of the hallux

Associated deformities	Number of feet involved
Valgus + rigidus + chisel toe	6
Valgus + rigidus + interphal valgus	3
Valgus + elevatus + chisel toe	2
Valgus + elevatus + interphal claw	2
Valgus + rigidus + interphal claw	1
Valgus + chisel toe + interphal fusion	1

Table 3 Deformities associated with hallux elevatus

Deformity	Feet affected	Feet at risk	Association with hallux elevatus %
Isolated hallux elevatus	6	20	30
Hallux valgus with hallux elevatus	11	114	10
Chisel toe with hallux elevatus	5	43	12
Interphalangeal claw with hallux elevatus	2	13	15
Interphalangeal hyperextention with hallux elevatus	15	83	18

Interphalangeal claw

Inability of the distal phalanx to be dorsiflexed on the proximal with assumption of a flexed attitude between 10° and 30° was defined as clawing and affected 13 toes, six of these developed a symptomatic dorsal callosity over the interphalangeal joint No less than 12 cases were combined with hallux valgus, however, the thirteenth was accompanied by 20° of medial tortus, a metatarsal head "bunion" and 12° of hallux valgus Thus a strong association with hallux valgus and tortus is established In addition, interphalangeal joint erosion and destruction was absent in 12 of the 13 cases, suggesting that rheumatoid disease at this level is an unimportant factor in the aetiology of this deformity No attrition ruptures of extensor hallucis longus were seen and no significant neurological deficit demonstrated

Interphalangeal valgus

Valgus deviation of the distal on proximal phalanx of more than 5°, measured by standing radiographs (Figure 1a), was observed in 13 feet achieving a maximum of 30° in two feet Callosities of the "bunion" type were present on the medial aspect of this joint in three cases causing minor discomfort, and in five other cases concurrent "chisel toe' was a complicating factor Curiously, accompanying hallux valgus was significant in one foot only Erosive and destructive changes seen in the interphalangeal joint of eight halluces indicate the importance of articular damage in establishing joint instability and hence deformity

Interphalangeal fusion

Four toes fused spontaneously at the distal joint in the presence of disease of long duration and extensive radiological damage in the metatarso-phalangeal tarsal and ankle joints of all cases Hallux rigidus, including two metatarso phalangeal joint fusions, was observed in all four and severe concurrent hallux valgus in three cases One joint fused in 25° of dorsiflexion and the remainder in the neutral position One first ray fused at the distal, proximal and basal metatarsal joints in addition to which the tarsus and ankle had fused creating a bony continuity from the distal phalanx to the proximal tibia thus eliminating functional mobility in the leg below the knee joint

Dislocated first metatarso phalangeal joint

Complete joint dislocation is rare in contrast to subluxation, whether valgus tortus or elevatus Three dislocated great toes were seen, all of which were displaced laterally between the first and second metatarsal heads, the proximal phalanx taking the sesamoids with it (Figure 9) and all ankylosed or fused in the dislocated position despite co existing valgus and tortus deviation No dorsal displacement was observed in contrast to

However, in this disease deformities are often multiple and complex, extremely painful and crippling and commonly influenced by joint changes elsewhere in the foot and more proximally. When present *pre-existing problems* are *aggravated by the disease* and as a corollary these problems may determine the ultimate direction and type of rheumatoid deformity, e.g., the mobile flat foot becomes a stiff extremely valgus foot, or the hallux rigidus becomes more rigid and precipitates a 'chisel toe'.

Terminology

In the English literature, this subject is muddled in several ways particularly by confusion between anatomical terms and clinical descriptions, *the former* utilising the median limb axis and the latter the median body axis as reference lines (Figure 11). Thus one arrives at the ambiguous proposition that relative overaction of the adductor hallucis *muscle is a* factor causing or *aggravating hallux valgus*, whereas *adduction indicates* medial and valgus indicates lateral deviation. Whilst the application of the median limb axis with pre- and post-axial margins to compare the human foot with other species is of considerable phylogenetic interest, it is irrelevant to patients who are not quadrupeds. *Furthermore, one foot cannot* function normally without its complementary fellow and therefore the mid line between weight bearing feet, that is the median body axis, is a logical reference line. Acceptance of this axis would necessitate revision of adductor hallucis as abductor hallucis and vice *versa*.

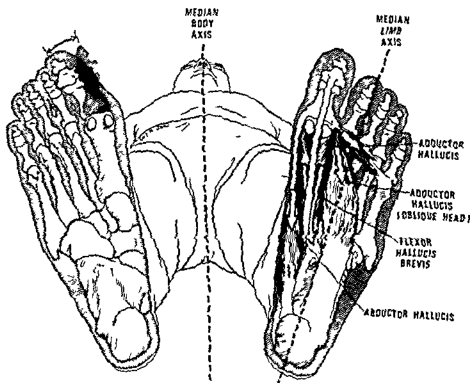


Figure 11. Diagram to show the inappropriate nomenclature of the so called adductors and abductors of the hallux with reference to the median body axis and the median limb axis.

Table 5 Deformities associated with hallux valgus

Deformity	Feet affected	Feet at risk	Association with hallux valgus %
Isolated valgus	47	114	41
Rigidus with valgus	33	55	60
Chisel toe with valgus	20	43	47
Elevatus with valgus	11	20	55
Interphalangeal claw with valgus	12	13	92
Interphalangeal valgus with hallux valgus	1	13	8

Table 6 Deformities associated with hallux rigidus The mobile and immobile types are combined

Deformity	Feet affected	Feet at risk	Association with rigidus %
Isolated hallux rigidus	14	55	25
Hallux valgus with hallux rigidus	33	114	29
Chisel toe with hallux rigidus	14	43	33
Interphalangeal claw with hallux rigidus	1	13	8
Interphalangeal valgus with hallux rigidus	0	13	0

Table 7 Deformities associated with chisel toe

Deformity	Feet affected	Feet at risk	Association with chisel toe %
Isolated chisel toe	8	43	19
Hallux valgus with chisel toe	20	114	18
Hallux rigidus with chisel toe	14	55	25
Hallux elevatus with chisel toe	5	20	25
Interphalangeal valgus with chisel toe	5	13	38

seen with interphalangeal valgus (Table 6)

"Chisel toes" were observed in 22 per cent of the feet at risk and complicated a similar percentage of valgus, rigidus and elevatus groups, its association with interphalangeal valgus was 38 per cent (Table 7)

DISCUSSION

To some observers the foregoing analysis may complicate what appear mundane problems of hallux valgus hallus rigidus or bunions, often diminished by more important co-existent disabilities This is not our objective for we believe detailed consideration assists clarification and interpretation of the patient's symptoms promoting a rational aproach to management, particularly operative treatment Despite the protean nature of rheumatoid arthritis, undoubted patterns of incapacity and deformity are found suggesting causal factors which are helpful in prognostication

Clearly these deformities are not specific to rheumatoid arthritis for similar if less disabling changes result from congenital, developmental, traumatic, metabolic and degenerative causes, moreover, one cannot assume absence of deformity prior to the onset of rheumatoid arthritis

curtails markedly any remaining propulsive capacity in the hallux

If there is a valgus attitude, and a large proportion of rheumatoid feet are so aligned the weight is concentrated towards the medial foot margin and hence plantar and medial aspects of the hallux In contrast the varus attitude produces abnormal loading of the lateral foot margin and elevation of the first metatarsal, which may fail to make ground contact causing compensatory plantar flexion of the hallux and occasionally hallux flexus deformity

Thus the type and degree of great toe deformity can be determined by the attitude of the foot, which is dependent on pathology in the proximal joints of tarsus and ankle and which in turn may reflect changes yet more proximally, as for example, when genu valgum aggravates pes valgus, and external rotational hip contracture alters the attitude of the foot

In summary, the factors contributing to great toe symptoms and deformity in the walking patient are primarily preexisting deformity, the activity and extent of rheumatoid changes in the halluceal joints ground friction and shoe friction These are modified by body weight, heel height, the foot attitude determined by proximal disease and the lesser toe disposition More remote factors are the presence of oedema, ischaemia, anaesthesia poor muscular control walking incapacity, upper limb inability to control sticks and crutches, the presence of other diseases and probably drug therapy, e g , steroids and analgesics

Pathological and clinical considerations

Early disease results in synovial swelling and joint effusions unassociated with measurable deformity of the hallux as defined above, but nevertheless associated with acute symptoms as unyielding shoes precipitate containment friction and pressure If synovial infiltration is temporary in nature, minimal or no permanent bone or joint changes follow Persistent swelling, however, produces stretching of ligaments and joint capsules, and more chronic disease may invade cartilage and bone causing structural joint damage with resultant stiffness and deviation If ligamentous laxity or stretching is the main feature, then deformity may still arise and indeed ultimately be severe due to the influence of weight-bearing and footwear In many feet articular structural damage and ligamentous laxity coexist

We postulate articular damage leads to ankylosis and ultimately induces fusion at the metatarsal base rigidus and fusion at the metatarsal head and occasionally valgus but rarely fusion at the interphalangeal joint Likewise ligamentous laxity with minimal cartilaginous destruction provokes varus of the metatarsal valgus of the proximal phalanx and hyperextension of the distal phalanx Therefore concurrent ankylosis and joint laxity produce combined hallux valgus with hallux rigidus, or hallux rigidus with 'chisel toe', or hallux valgus with hallux rigidus and 'chisel toe'

It is of interest to compare the behaviour of the first with the lesser metatarso-phalangeal joints 1) Whilst the lesser toes on occasion sublux laterally and in the case of the little toe medially, the pattern of dorsal subluxation leading to dorsal dislocation is common and usually symmetrical, contrasting with the uncertainty of halluceal behaviour which is often strikingly divergent between right and left great toes 2) The common dislocation of the lesser toes contrasts with its rarity in the hallux 3) Whilst fusion of the first metatarso-phalangeal joint is not common it is extremely rare in the lesser metatarso-phalangeal joints 4) The second to fifth toes commonly develop claw and hammer deformities whilst this is seldom seen in the hallux 5) Barefoot contact between the lesser toes and the ground is frequently lost

Clinical terminology itself is not without inexactitude as mentioned earlier, hallux rigidus is commonly correlated with limited mobility rather than its literal meaning of complete rigidity, and hallux valgus denotes deviation in one plane despite displacement in the first ray being three dimensional Moreover, these descriptions indicate one component only of the disordered anatomy and do not explain the actual aetiology, e g rheumatoid disease, or even suggest the joint pathology, e g arthritis or subluxation One cannot easily discard the time-honoured phrase 'hallux valgus' despite its limitations and as a consequence there is a need for the terms 'elevatus' and 'flexus' to describe deformities which are often co-existent with hallux valgus or varus and yet in a plane at 90° from them If one accepts the precision of these terms, it is reasonable to denote any accompanying rotational deformity It is appropriate to use Latin terminology and we have suggested 'tortus' as the equivalent of 'twisted' without, however, indicating the direction of twist In a particular case a full description might be 'hallux valgus, elevatus et tortus' This precise if somewhat pedantic formula also hints at particular instability of the first metatarso-phalangeal joint suggesting to us the less precise yet accurate and possibly more acceptable 'hallux subluxans' Alternatively in rheumatoid arthritis it is appropriate to say 'rheumatoid hallux' as indicative of a disease understood to cause complex deformity of all the joints of the first ray

Functional consideration

Whilst the great toe is not so versatile as the thumb, its contribution to foot function is as vital as the thumb is to the hand Analogies of structure between the two digits are obvious and it has been and remains tempting to emphasise similarity of function based on structural resemblance As Wood Jones (1944) maintains the foot is a specialised organ permitting man's erect posture and is in no way an imperfect hand

Fundamentally, the great toe functions on terra firma, firstly to support body weight and assist balance, secondly to initiate propulsion by virtue of the powerful muscles attached to it During walking the traction exerted by the forefoot requires friction between plantar surface and the sole of the shoe, and between shoe and the unyielding ground In a temperate climate the shoe protects and necessarily encloses the foot submitting the hallux to additional medial and dorsal friction dependent on the rigidity and tightness of the shoe and the spread of the loaded foot These two sources of friction, one inevitable and consequent on the erect posture under the influence of gravity and the other avoidable and dependent on footwear selection, must be clearly distinguished

The dynamic gait of normal walking requires movement of all foot joints including those of the hallux which concurrently must take weight The actual range of movement will depend on stride length and gait speed In contrast, the disabled rheumatoid patient tends to use a 'static' gait because pain and joint disorganisation diminish and prevent movement accentuating the passive supportive role of the foot In this situation the hallux is a forward extension of the foot platform, in which it may be isolated for the lesser toes are frequently subluxated or dislocated and thus not in contact with the ground The actual degree of contact varies with heel height Thus if the ankle is sufficiently plantar-flexed by raising the heel the subluxated toes become weight-bearing with the penalty of increased thrust on the forefoot and painful shoe containment, in addition to sustaining the upward pressure from the ground In practice the patient discovers a low heel is more comfortable though it

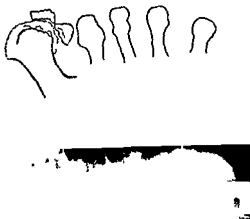


Figure 13 Tangential X ray of the metatarsal heads in a patient with rheumatoid hallux valgus The first web space is abnormally wide and the eroded sesamoid bones are dislocated between the first and second metatarsal heads

Valgus may arrest at any stage, for example when joint destruction introduces concomitant rigidus with ankylosis, or the second and lesser toes are resistant to disease and maintain a lateral buttress Valgus may diminish after dislocation ensues although the metatarsal head becomes more prominent (Figure 9) We believe that selection of suitable shoes will arrest hallux valgus in some feet

Chisel toe At surgical exploration we have failed to demonstrate attrition rupture of flexor hallucis longus in this syndrome Possibly hyperextension of the distal joint is related to congenital ligamentous laxity, which is common enough in the general population, and aggravated by rheumatoid arthritis and by steroid therapy in some cases Others develop compensatory distal hyperextension in the presence of hallux rigidus

Hallux elevatus More puzzling is the association of hyperextension of the proximal and of the distal phalanx in 15 (75 per cent) cases of hallux elevatus We surmise the primary lesion is due to metatarso-phalangeal damage which initiates a protective posture in dorsiflexion enabling extensor hallucis longus to secure mechanical advantage, establishing a vicious circle of muscle imbalance on both this and the interphalangeal joint The latter being generally free of disease readily adopts a hyperextended position and any attempt to flex it inevitably tends to flex the damaged proximal joint, causing pain and protective extensor spasm leading finally to persistent hallux elevatus

Interphalangeal claw To account for the mechanism of clawing, explanation of its association with severe hallux valgus and tortus accompanied by any undamaged interphalangeal joint is required We suggest muscle imbalance at the interphalangeal joint develops in favour of flexor hallucis longus as a sequel to dislocation of the sesamoids and subluxation of the proximal phalanx laterally, compounded by medial rotation of the toe The rotation hinders effective weight bearing by the distal phalanx ensuring unhampered action of flexor hallucis longus and consequent clawing in what is virtually a valgus attitude promoted by dislocation of the second toes and no doubt ill fitting footwear Clawing is not uncommon in the general population, frequently being accompanied by depression of the metatarsal head and compensatory hyperextension of the proximal phalanx Such a basis might account for the two feet deformed by elevatus additional to valgus and clawing

Metatarso-phalangeal dislocation Outside this series, dislocation of the proximal phalanx dorsally has been observed in two feet, in both cases the sesamoids were observed widely separated from the proximal phalanx accompanied by severe interphalangeal clawing As far as lateral dislocation is concerned, radiographs of other toes in the series suggest a pre-dislocation position (Figure 14), and lead to the conjecture that erosive collapse of the medial phalangeal base at



Figure 12 Photograph of a great toe with the soft tissue attachments to the proximal phalanx The metatarsal head has been removed to show the spherical socket in which it lies composed of the phalangeal base sesamoid bones and the surrounding soft tissues The cartilage surfaces have been coloured in order to highlight them

due to dislocation but persists beneath the great toe even if grossly deformed, the one exception being hallux elevatus One cannot escape the conclusion that the first metatarso-phalangeal joint is not only more important functionally, more diverse pathologically and more disabling clinically, but fundamentally distinctive structurally from the other metatarso-phalangeal joints We believe one important factor is the presence and contribution of the sesamoids beneath the first metatarsal head and most important is their close and strong musculo ligamentous connections to the base of the proximal phalanx under most circumstances Indeed we suggest that the sesamoids functionally extend the phalanx proximally creating a deep 'socket for the 'ball' of the metatarsal head (Figure 12), which explains why dislocation is rare, for the articulation is virtually a 'captured joint' Moreover, this capture enables alarming degrees of subluxation to develop and be maintained, e g 90° of hallux valgus, and dictates that although the sesamoids themselves may dislocate on the metatarsal head, the proximal phalanx adapts by rotating on its long axis medially with valgus and laterally with varus

Hallux valgus The strong tendinous and muscular attachments securing the sesamoids to the phalanx are also components in the muscle imbalance at the metatarso-phalangeal joint after and possibly before subluxation reaches 20° The lateral half of flexor hallucis brevis and adductor hallucis secure a mechanical advantage which overcomes the medial half of flexor hallucis brevis and the abductor (Figure 11) Progressive hallux valgus may be encouraged by unsuitable footwear and metatarsus primus varus if not initiated by them also dislocation and lateral drift of the lesser toes leave space which the hallux can occupy Metatarsus primus varus may be aggravated by severe valgus when the strong lateral muscles act on the phalanx and sesamoids which may push the metatarsal head medially, in particular, when the lateral sesamoid dislocates between the first and second metatarsal heads (Figure 13)

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PROCEEDINGS OF THE DANISH ORTHOPAEDIC SOCIETY

Copenhagen 23, 30 April 1977

EDITOR N J HOLM

CUBITAL TUNNEL SYNDROME TREATED WITH SIMPLE DECOMPRESSION

Per B Thomsen

A [illegible] up study (observation time 7 months to 5 years) of 32 decompression operations in 31 patients with cubital tunnel syndrome treated during a 5 year period revealed complete recovery in 16 patients varying improvement in 13 and no improvement in 3 patients

This method gives results equal to those obtained with the traditional operative methods—anteposition and medial epicondylectomy—i e about 75 per cent excellent plus good results The method is easy and rapid to perform and free of complications

A case of supracondylar process of the humerus with compression of the ulnar and median nerves treated with subperiosteal resection of the spur is discussed

AVASCULAR NECROSIS OF THE TROCHLEA OF THE TALUS

Jørgen Ewald Lorentzen

On the basis of an analysis of 218 consecutive cases of talar fracture or subtalar dislocation it could be concluded that a connection exists between the morphology of the talar injury and the incidence of trochlear necrosis This connection can be explained by the relation of the injury to the anatomical course of the three main vascular supplies of the trochlea After injuries involving one of the three main channels the incidence of necrosis is about one in twenty after injuries involving two main channels it is one in four and if the injury involves all three main vascular supplies so that for a time the trochlea is entirely avascular necrosis will occur in about two thirds of the cases Thus on the basis of our knowledge concerning the vascular supply of the trochlea it is possible to assess the risk of osteonecrosis according to the morphology of the individual talar injuries

LESIONS OF LARGE ARTERIES [illegible]

[illegible]

Sixteen patients with lesions of large arteries complicating fractures or dislocations of the lower limbs are presented Only four of the patients were brought to vascular surgical treatment within 6 hours after the injury and good end results without residual disability were obtained in all four patients Amputation proved necessary in seven of the 12 patients who received vascular surgical treatment more than 6 hours after the injury and two patients developed permanent disabilities in the form of muscular necroses and pareses Thus only three of the patients in whom vascular surgical treatment was instituted at a late stage did not develop permanent sequelae The explanations for the late treatment are defective primary diagnosis and prolonged transport of the patients On the basis of these findings early arteriography or transfer of patients suspected of having arterial lesions is recommended or possibly, the summoning of a vascular surgical team could be considered

AMPUTATIONS IN A DANISH COUNTY CHANGES OVER 5 YEARS IN INCIDENCE AND LEVEL

Steen Christensen

Following a previous investigation of amputations in a Danish county (1961–1971) a new study (1975/76) showed a slight increase in incidence, from 13 9 to 18 2 per 100 000 inhabitants per year It is now possible to preserve the knee in 50 per cent of the diabetic patients and in 23 per cent of the arteriosclerotics

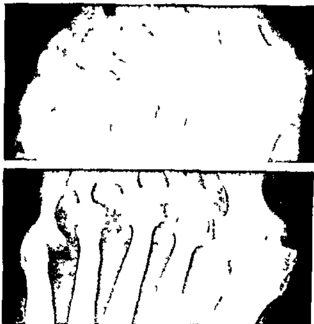


Figure 14 Predislocation

A Collapse of the medial corner of the proximal phalanx in progress

B Proximal phalangeal erosion with integrity of the medial corner of the phalanx preventing complete dislocation

the attachment of abductor hallucis is a necessary prelude to dislocation perhaps hastened by previous valgus and tortus deviation Such collapse is a sequel to severe joint destruction which probably facilitates the tendency to subsequent fusion To emphasise a point already postulated, the sesamoids remain anatomically tied to, and thus functionally an extension of, the proximal phalanx forming a plantar ledge preventing dorsal dislocation on the metatarsal head but ensuring rotation additional to valgus (Figure 12)

We suggest that weight-bearing prevents plantar dislocation and assume that footwear stops medial dislocation

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Correspondence to Richard K Jacobs, M D M R C P Torbay Hospital Lawes Bridge Torquay TQ2 7AA, England

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THE OSTEOCLASTOMA AN EVALUATION OF MALIGNANCY IN RELATION TO MICROSCOPIC FINDINGS

T Schiødt I Dissing J Heerfordt & O Sneppen

A 10 year series of bone tumours from Rigshospitalet" and Radiumstationen, Copenhagen contained 12 osteoclastomas the malignancy of which was graded by Jaffe's method Two cases were classified as grade I five as grade II and five as grade III Clinical follow up showed that four patients had died from their tumours one died in an accident—presumably with recurrent tumour while seven were alive six of whom showed no clinical recurrence Apparently the correlation between degree of malignancy and clinical course was quite good but the material is too small for reliable conclusions The general attitude in the literature to malignancy grading is reserved and any case of osteoclastoma should be considered potentially malignant

TECHNETIUM SCINTIGRAPHY OF INTRACAPSULAR FRACTURES OF THE FEMORAL NECK

D Zdravkovic A B Christensen H Erichsen O Harling & S P Nielsen

A prospective investigation of 25 patients with intracapsular fractures of the femoral neck was carried out with special attention to the early diagnosis of necrosis of the femoral head Technetium scintigrams were made 14 days 3 6 and 12 months after the fracture The results showed that patients with necrosis of the femoral head had increased activity over the caput but the difference was not statistically significant

The treatment of 19 patients with histologically proven chondrosarcomas was amputation in 8 local excision in 7 and X ray treatment in 3 cases Thirteen patients survived more than 2 years eight more than 5 years and two more than 10 years Six developed local recurrences four of them *after excisions* and two after subtotal hemipelvectomies Four patients developed pulmonary metastases

Chondrosarcoma runs a slow course and shows a great tendency to local recurrence and late pulmonary spread The histological diagnosis is very difficult and discrepancies between histological picture and clinical course are found Surgery is the only treatment

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STABILITY OF THE HIP IN CHILDREN EVALUATED FROM A SINGLE RADIOGRAPH
J Reimers

Stability of the hip can be evaluated on an antero posterior radiograph of the pelvis by determining the percentage migration of the femoral head beyond the acetabular rim Out of 32 Danish orthopaedic departments four employ a single radiograph the others use two or more positions Sixty six deformed hips in patients with cerebral palsy were studied in neutral and in maximum inward rotation A correlation coefficient of r = 0 89 was obtained and the differences in percentage migration were small enough to be ignored Since even a severely sub luxated hip will become reduced on abduction of the leg a single knees together antero pos terior radiograph suffices

EXPERIENCE WITH THE STANMORE TOTAL HIP REPLACEMENT
N J Holm K Mossing & K Jansen

A total of 205 operated hips were studied after a follow up time of from 1 to 5 years The mor tality was 2 per cent deep infection rate 1 per cent and luxation rate 5 per cent 177 patients were examined according to Merle d Aubigné and showed considerable gain in all three scores most markedly in the pain rating There were 25 cases of slight complications and 20 cases of serious complications 10 patients required var ious forms of revision

MALACIA OF THE OS LUNATUM TREATED WITH SHORTENING OSTEOTOMY OF THE RADIUS
J Ovesen

In the period 1970 1976 seven patients—six men and one woman—have been treated for ma lacia of the os lunatum In all cases the treat ment was osteotomy to reduce the length of the radius by 5 mm The average age of the patients was 37 years and the average observation time was 34 months

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The vascular changes in rabbits after amputa tion were studied *in vivo* with arteriography af ter intracardial injection of contrast

In the amputated extremity an initial vaso constriction of the arteries was found There after changes were observed in arteries and veins both in the operated and contralateral ex tremities depending on the level of amputation and the manner in which the stump was closed When no myoplasty was carried out arterio venous shunts were formed in the stump caused by the inactivity of the muscles Myoplasty counteracts muscle inactivity and the develop ment of arteriovenous shunts and so improves the muscle blood flow in the stump

PRELIMINARY EXPERIENCE WITH ARTHROSCOPY OF THE KNEE JOINT USING THE DYONICS NEEDLESCOPE"
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At the Department of Orthopaedic Surgery Odense Hospital arthroscopy of 86 knee joints using the Dyonics Needlescope (standard mo del) was performed over a 4 month period The patients were predominantly 20 to 40 year-old males An antero lateral approach under general anaesthesia was routinely employed No com plications were observed In 55 knees with pri mary indication for surgery the clinical diag nosis was correct in 39 cases whereas arthros copy yielded 49 correct preoperative diagnoses

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PROCEEDINGS OF THE FINNISH ORTHOPAEDIC ASSOCIATION

Helsinki 12 March 1977

EDITOR A ALHO

ELECTRICAL STIMULATION OF FRACTURE HEALING

A J Aho H Aro & T Ekfors
Department of Surgery and Department of Pathological Anatomy
Turku University Central Hospital

We examined the effect of asymmetrical alternating current on the bone healing process in the rabbit antebrachium The voltage supplied simulated a physiological pattern of stress generated electrical potentials in bone A transistorized multivibrator (Ollituote Oy Finland) delivering asymmetrical alternating current was used The current suppl ed had positive and negative peaks (+ 22 μA and — 18 μA in the radius group + 100 μA and — 100 μA in the ulna group) and a small unidirectional current (+ 2 μA in both groups) The frequency was 0 8 Hz pulse duration 8 ms and voltage limit 1 V

In the radius group the current was led into the osteotomized bone with teflon insulated platinum iridium leads In the ulna group the osteotomy site was externally transfixed with two Kirschner wires which were used as electrodes

In the two stimulated groups histological studies revealed an activated osteogenesis near the electrodes, particularly in the *periosteum* which was more pronounced than the reaction at the fracture site Both electrodes induced osteogenesis In the control groups the osteogenic reaction around the electrodes was either minimal or else non existent

Orthopaed c Hospital of the Invalid Foundation Helsinki

Earlier studies have shown that free periosteum stripped from the tibia with a scalpel has a strong osteogenetic capacity (Ritsila et al 1972 *Scand J Plast Reconstr Surg* 19 19) Periosteum alone and periosteal grafts attached to 200 μ thick cortical bone were grafted from the tibia to a lumbar vertebra in 6 week-old rabbits The grafts were fixed bilaterally in the same vertebra between the spinous and mammillary processes The rabbits were killed 3 7 14 21 and 28 days later and osteogenesis was examined histologically It was found that freely stripped periosteum had better osteogenetic power than the 200 μ thick osteoperiosteum The new bone was formed by the osteogenetic cells of the cambium layer In the present study the osteoperiosteal grafts were relatively thick A further study using thinner grafts is being performed

ENDOPROSTHETIC REPLACEMENT OF THE KNEE JOINT

Par Slatis & Uolevi Kankaanpaa
Division of Orthopaedic Surgery and Traumatology Surgical Clinics Helsinki

Twenty-one patients with rheumatoid arthritis and eight patients with osteoarthritis of the knee were treated with an endoprosthetic replacement of the deranged joint surfaces The main indications in addition to pain were severe lateral instability in nine knees and flexion contracture ranging from 20 to 50° in 19 knees Two types of prostheses were used viz., the Geomedic and the Marmor modular knee Follow up averaged 12 months Arthroplasty provided almost complete relief of pain in 20 patients corrected lateral stability in seven out of nine unstable knees and relieved completely the flexion contracture in 11 out of 19 knees The average range of movement increased from 78° preoperatively to 90° at follow up

tion while telescoping of the implant was encountered in 18 cases leading to bony support and stable weight transmission over the fracture line Penetration of the screw occurred in only two patients but in neither case was re operation indicated

In conclusion the sliding screw plate is recommended in the treatment of unstable trochanteric fractures, as it permits early weight bearing and technical errors are not encountered

were operated on during the period 1974–1976 The mean age of the patients was 29 8 years and the time interval between the trauma and surgery was more than 3 years The pseudarthrosis was in each case located in the middle third of the clavicle The indication for surgery was pain A skin incision was performed craniocaudally to avoid damaging the cutaneous nerves The ends of the pseudarthroses were renewed and the reposition fracture was fixed with AO semitubular plates and cancellous bone transplants from the iliac crest It was possible to treat a 1 inch defect successfully without bone interposition Postoperative immobilisation was maintained with a collar and cuff for 3 weeks All operated pseudarthroses consolidated and the patients returned to work within 2 months of the operation In primary treatment of fractures of the clavicle the conservative method gives good results in most cases and in the treatment of pseudarthrosis an AO semitubular plate with cancellous bone transplantation is recommended

EARLY COMPLICATIONS OF DISLOCATION OF THE HUMERUS

M Pasila H Jaroma O Kiviluoto & A Sundholm
Department of Orthopaedics and Traumatology Helsinki University Central Hospital

Complications of traumatic dislocation of the humerus during the period 1973 1976 were analysed in a prospective study The clinical examination was first made in the emergency department and later repeated in the department of physiotherapy The function of the rotator cuff peripheral pulses and motor and sensory function of the upper limb were examined

Sixty three patients out of 238 (26 per cent) showed the following associated lesions brachial plexus 29 rotator cuff 28 and axillary nerve 21 Complications were more frequent in the age group over 50 years ($P < 0.001$) and in patients performing manual labour as opposed to those performing intellectual work ($P < 0.05$) If the humerus was dislocated for longer than 12 hours the frequency of complications was higher ($P < 0.01$)

The importance of early reduction is emphasized

INTERCONDYLAR Y SHAPED FRACTURES OF THE HUMERUS

Vappu Uspad
Department of Orthopaedics and Traumatology Helsinki University Central Hospital

158 patients aged 15–90 with 159 intercondylar Y shaped fractures of the humerus were treated during the period 1960 1972 Two thirds of the 91 female patients were 55–90 years of age, almost half of the male patients were aged 15–35 years 114 patients with 115 fractures were reexamined the average follow up period being four and a half years According to the Riseborough Radin classification there were 24 cases of type I, 44 cases of type II, 44 cases of type III, and 27 cases of type IV fracture The female patients had had low energy accidents (falling) the male patients mainly high energy accidents (working traffic) One fracture in four was open Four primary nerve injuries were noted 80 patients were treated conservatively closed reduction and plaster cast immobilization or skeletal traction and plaster cast were used 78 patients were treated operatively 34 cases within the first 24 hours A great variety of fixation methods were used Vitallium screws and plates, and Kirschner wires were used throughout the whole period, with AO-osteosynthesis being the most popular method in the latter years 19 cases of postoperative nerve injuries were observed 10 patients developed chronic fistulation and five of them had open fractures Five cases of pseudarthrosis were noted two of them after conservative treatment

TREATMENT OF FUNCTIONAL DISORDERS AFTER MALPOSITION OF FRACTURES OF THE DISTAL RADIUS

K A Solonen & T Telaranta
Orthopaedic Hospital of the Invalid Foundation Helsinki

Eighty six patients with malposition after a fracture of the distal radius are reviewed. The patients initially had conservative treatment at different out patient departments The deformity was observed to limit movement of the radioulnar joint but movement of the radiocarpal joint was also restricted in most of the cases

Depending on the degree and the nature of the deformity and the limitation of joint movement two methods were used The worst deformities were corrected by a distal wedge osteotomy of the radius according to the angulation The distal fragment was fixed in the corrected position with two Kirschner wires Most frequently a modified Darrach procedure was included in the operation the length of the ulna resected did not exceed 2 cm The postoperative plaster splint was removed after 6 to 8 weeks In the cases where the deformity caused limitation in pronation supination only a distal resection of the ulna was considered to be sufficient

Median nerve compression symptoms were reported in 19 per cent of the patients These symptoms disappeared in most of the patients

ARTHROPLASTY OF THE KNEE JOINT WITH SPECIAL REGARD TO COMPLICATIONS

V Vahtonen
Aurora Municipal Hospital Helsinki

A study of arthroplasty of 73 knee joints was made with an average follow up of two and a half years All operations were performed by the same orthopaedic surgeon in the department of general surgery Modular and polycentric prostheses were used in most cases and the average age of the patients at the time of the operation was 60 years Most had rheumatoid arthritis The rate of deep infection was 5 5 per cent (four cases) and that of failure 18 per cent Fractures of the prosthesis or bone were found in five knees All the fractures were in the medial compartment of the knee joint Loosening of the prosthesis without infection or other complications was found in three cases all of which became apparent within 1 year of the operation All failures were reoperated on An arthrodesis was performed on seven knees i e on about 10 per cent These knees were evaluated as poor at the late follow up stage The prosthesis of five patients was changed and one knee was treated by closed irrigation All infections healed during the follow up The best results were achieved with the Geomedic and St Georg Schlitten prosthesis models

OPERATIVE TREATMENT OF THE RHEUMATOID CERVICAL SPINE

Uolevi Kankaanpää
Division of Orthopaedic Surgery and Traumatology Surgical Clinics Helsinki

Rheumatoid arthritis more often involves the upper than the lower part of the cervical spine In the upper cervical spine dislocation is caused mainly by ligamentous destruction Because of the large upper medullary canal the subluxation seldom results in medullary symptoms Radicular pains are however quite common In the lower cervical spine dislocation is caused by bony destruction of articular facets Because of the narrower lower medullary canal even slight dislocation may be dangerous

Since 1972 28 patients have been operated on at Rheuma Foundation Hospital Heinola and Surgical Clinics Helsinki Brattström s method of occipito axial fusion with cement and bone was used in 14 cases (Brattström & Granholm 1973 *Orthopade* 2 118 120) Gallie atlanto axial fusion was performed in seven patients The remaining seven patients suffered from C3 C6 dislocations They were operated on using Rogers method i e simple bone transplantation or laminectomy plus lateral fusion

One tetraplegic patient showed no improvement whereas the two tetraparetic patients recovered almost completely At the follow up of 23 patients their subjective evaluation of the result was good in 15 fair in 5 and unimproved in 3 Two complications were recorded one infection (necessitating the removal of cement 6 months later) and one broken wire between the atlas and cord (with no medullary injury but requiring removal of the wire)

There seems to be an increased tendency for the occurrence of lower cervical dislocations 4-5 years after occipito axial fusion

STRESS HORMONES LIPIDS AND COAGULATION IN TRAUMA PATIENTS WITH AND WITHOUT FAT EMBOLISM A COMPARATIVE STUDY 1 YEAR AFTER SEVERE TRAUMA

V Avikainen K Willman & P Rokkanen
Orthopaedic Department Central Hospital of Central Finland Jyväskylä

The question of why some patients develop fat embolism syndrome (FES) while others with similar injuries do not remains unsolved Ten patients with FES were compared with 10 patients with similar injuries without FES at least 1 year after trauma The following blood tests were performed Hb leucocytes platelets protein and lipid electrophoresis ACTH cortisol TSH HGH insulin glucose NEFA certain coagulation studies α antitrypsin and antithrombin III In FES platelet counts were higher especially after ergometric stress ($P < 0.01$) More numerous petechiae were observed in the FES group in a Rumpel Leede stasis test Cholesterol was somewhat higher in FES and the alpha/beta ratio in lipoprotein electrophoresis somewhat smaller Cortisol was lower after stress in the control group ($P < 0.05$) Low GH values were observed in the FES group ($P < 0.05$) Blood glucose was pathological in three patients in the FES group and the values rose after ergometric stress while in the control group glucose was normal in all and decreased after stress in most Half the patients with FES had a familial history of diabetes against none in the control group Urinary catecholamine were somewhat higher in FES but the reaction to stress was similar in both groups

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after the ostectomy, but occasionally a discission of the volar carpal ligament was needed One patient developed a full blown picture of a shoulder hand finger syndrome postoperatively In the other patients the result was beneficial

Osteotomy of the radius seems to be an advisable adjunct to the resection of the ulnar head in cases where the angular deformity of the radius is so severe that it significantly impairs radiocarpal movement

IMAGE STORE FLUOROSCOPY IN SURGERY OF THE FRACTURED HIP

Kari Pietilä & Par Slatis
Division of Orthopaedic Surgery and Traumatology Surgical Clinics Helsinki

The recent development of radiographic image store devices permits the collection of consecutive radiographic images obtained during operative procedures With image stores the automatic exposure time required for each picture is short and therefore the irradiation is correspondingly reduced –and is considerably shorter than that with conventional pedal controlled continuous fluoroscopy

The value of image store fluoroscopy in surgery of the hip was assessed in 54 patients whose fractures of the femoral neck or trochanteric region were treated with fixed angle AO/ASIF nails In 34 patients reduction of the fracture and positioning of the nail were checked with conventional fluoroscopy In 20 patients this evaluation was performed with a 100 picture store (VAS IS 100) attached to the X ray device The mean time of irradiation in the first group was 385 ± 168 seconds (S D) and in the second group 86 ± 48 seconds (S D) Thus image store fluoroscopy appreciably reduced the period of irradiation during the operation and additionally facilitated the accurate radiographic evaluation of each step in the operation

POST TRAUMATIC SUBLUXATION OF THE PATELLA

A Alho
Section of Orthopaedics and Traumatology University of Bergen Hospital Norway

Twelve patients were treated operatively for a subluxation of the *patella* The cause was traumatic in all cases The primary treatment had been conservative or none at all Both sexes were equally represented the *age* range was 18 44 years The symptoms and signs were pain on weight bearing (all) giving away (10) momentary lockings (4) pain on resisted extension (5), and lateral instability of the patella (9) A tendency for subluxation was demonstrated in six cases by using Merchant X ray projection (*J Bone Jt Surg* 1974 56 A, 1391) No pre existing deformities of the knee were observed A release incision of the lateral retinaculum was used in three cases Campbell technique with release in six cases Roux Goldthwait operation in one case and a combination of all these in two cases Plaster immobilization was used for 2 to 6 weeks Only detached fragments of chondromalacia present in seven cases were removed Seven patients were totally symptom free and five had some pain on weight bearing *after a follow up period of ½ to 3 years* It was concluded that post traumatic subluxation of the patella is a distinct entity to be kept in mind in the flexion abduction external rotation injuries

OSTEOTAXIS IN TREATMENT OF COMPLICATED FRACTURES OF THE LOWER EXTREMITY

S Santavirta & F Karaharju
Division of Orthopaedic Surgery and Traumatology Surgical Clinics Helsinki

Hoffman s osteotaxis is a therapeutic alternative in the treatment of severe primarily complicated fractures and infected pseudarthroses of the lower leg and femur From 1973 to 1976 11 cases of this type were treated In seven of these cases the fracture was located in the tibia In three cases osteotaxis was the primary treatment and in the remainder osteotaxis was chosen after primary treatment had failed In six patients primary treatment with osteosynthesis had resulted in an infection and osteotaxis was chosen for further treatment In the first stage the material of osteosynthesis was removed and a lixation was performed In the second stage when the infection had ceased bone transplantation was performed while the external fixation stabilized the fracture area The average time of frame immobilization was 150 days One case resulted in amputation below the knee Three fractures failed to consolidate despite cancellous bone transplantation In seven fractures the osteotaxis resulted in consolidation In three of these cases bone transplantation had been necessary Osteotaxis can be recommended for the treatment of severe fractures with amputation often being the only alternative

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PROCEEDINGS OF THE NORWEGIAN ORTHOPAEDIC ASSOCIATION

Oslo January 15th, 1977

EDITOR ARNT JAKOBSEN

SYNOVECTOMY IN RHEUMATOID ARTHRITIS

Jens Teigland
Oslo Sanitetsforening Rheumatism Hospital
Oslo

The modern concept of systematic synovectomy in rheumatoid arthritis was initiated by Vainio in 1951 The initial optimism has persisted in some clinics whereas others have expressed doubts regarding the long term results

After 5 years or more there seems to be freedom from pain in about 80–90 *per cent of cases* Recurrence of synovitis occurs in 20–30 per cent The destructive process is stopped or retarded A reduced frequency of recurrence is seen after operative techniques permitting maximal radicality of synovectomy Synovectomy in juvenile arthritis can normalize the disturbances of growth in the actual joint

In this hospital synovectomies are performed in all joints of the upper and lower extremities and are carried out as totally as is technically possible

SYNOVECTOMY OF THE ANKLE JOINT

Jan A Pahle
Oslo Sanitetsforening Rheumatism Hospital
Oslo

Sixty three cases of synovectomy of the ankle joint *are reported Eleven had juvenile arthritis* 50 had seropositive *rheumatoid* arthritis and two had psoriasis Their ages ranged from 7–66 years

An anterior midline and two curved incisions behind the lateral and medial malleoli with partial transection of the ligaments were used In 23 cases postoperative immobilisation for 3 weeks in a *plaster splint was used In 40 cases* active *movements* were started immediately Partial weight bearing was permitted *after 3 weeks*

Three years after the operation 46 patients are free from pain and swelling whereas 10 have tolerable pain. Of the remaining seven three have subsequently had an arthrodesis performed and one an arthroplasty Improved stability was obtained in 21 of the 38 cases with preoperative instability In 17 patients the range of motion was slightly reduced in 7 slightly increased

In the same period 21 primary ankle arthrodeses were performed These were triplearthrodeses if affection of the subtalar joint was present

ARTHROPLASTY OF THE ANKLE JOINT

Jan A Pahle
Oslo Sanitetsforening Rheumatism Hospital
Oslo

Total replacement arthroplasty of the ankle joint *ad modum* Thompson has been performed with satisfactory preliminary results in seven

Postoperatively all are pain free with good stability which the side flanges of the tibial prosthesis seem to contribute to The average *postoperative dorsiflexion* is 10° and plantar flexion 20° Correct alignment of the prosthesis has been made technically easier after a slight modification of the original procedure Active *exercises* are started *immediately* and *partial* weight bearing is allowed after 2 weeks

Arthrodesis of the *ankle joint* has not been performed in the last year If arthrodesis of the *subtalar joint is indicated* this should be *done* prior to the insertion of the ankle prosthesis

AMYLOIDOSIS IN RHEUMATOID ARTHRITIS

Gunnar Husby
Oslo Sanitetsforening Rheumatism Hospital
Oslo

A survey on amyloidosis in rheumatoid arthritis is given Rheumatoid arthritis is *an important* primary disease predisposing to secondary amyloidosis as 5 *per cent of the patients* get this complication

The major protein AA of secondary amyloid fibrils is of a non immunoglobulin nature A serum protein SAA *related to the amyloid pro*

tein AA is found in higher concentrations in diseases prone to secondary amyloidosis including rheumatoid arthritis. However, SAA is also increased in conditions without a predisposition to amyloidosis, quantitation of SAA can therefore not be used in the diagnosis of "risk", or early cases of amyloidosis.

Amyloidosis is a serious complication of rheumatoid arthritis. However, in many cases the prognosis seems to be better than thought previously. Such patients deserve the same, active therapeutic attitude as other rheumatoid patients.

HOFFA'S DISEASE

Paul Fevem
Oslo Sanitetsforening Rheumatism Hospital
Oslo

Four women, age 16–25 years, have been treated with excision of the fat pad of the knee joint, one bilaterally. Three have been relieved of their symptoms while in one the operation was performed too recently to judge the result.

The aetiology is discussed, trauma may be the cause. Once the condition occurs it seems that the patients enter a "vicious circle", and the treatment of choice is excision of the fat pad. Soft tissue X ray, and arthroscopy may be useful in making the diagnosis.

ATLANTO AXIAL LUXATION IN RHEUMATOID ARTHRITIS

Jens Teigland
Oslo Sanitetsforening Rheumatism Hospital
Oslo

A videotape was shown of the technique of radiological examination, the symptoms and signs and the operative fixation in atlanto axial luxation *ad modum Brattstrom Granholm*.

The videotape also dealt with a technique for measuring the spinal fluid pressure with a transducer, showing the special pressure pattern elicited by compression of the jugular vein with the head in a neutral position, in a ventroflexed and a dorsiflexed position. The videotape was produced in the Department of Rheumatoid Surgery in collaboration with the Department of Neurosurgery, Rikshospitalet, Oslo.

Oslo, February 12th, 1977

CLEIDOCRANIAL DYSOSTOSIS

Tore Grønmark
Telemark Central Hospital, Skien

One case of cleidocranial dysostosis is reported. The aetiology, clinical picture and treatment of the lesion are discussed. Pseudarthrosis of the clavicle and other clavicular abnormalities in cleidocranial dysostosis usually require no special treatment.

AN OPERATIVE TECHNIQUE FOR GENU RECURVATUM

Kåre Hadland
Telemark Central Hospital, Skien

A middle-aged woman with marked genu recurvatum caused by a previous hyperextension injury, was operated on using the following technique.

A long strip of the iliotibial band was dissected free, preserving the insertion on the anterior aspect of the tibia. The strip was passed obliquely backwards, and pulled through a hole drilled transversely and as far posteriorly as possible through both femoral condyles. From here the strip was passed obliquely outside the medial capsule, and under strong tension and with the knee in some degree of flexion, it was anchored on the anteromedial aspect of the tibia.

Immobilisation in a plaster cast was maintained for 3 months. The result was excellent.

SURGICAL TREATMENT OF DISLOCATION OF THE PERONEAL TENDONS

Tore Grønmark
Telemark Central Hospital, Skien

One case of dislocation of the peroneal tendons treated operatively by the method of Ellis Jones is reported. Early operation for dislocation of the peroneal tendons is advocated.

Oslo, March 12th, 1977

ORTHOPAEDICS IN A REGIONALIZED HEALTH SERVICE SYSTEM HEALTH REGION 5

Einar Sudmann
Regional Hospital in Tromsø, Tromsø

In Norway orthopaedic patients, except those with acute trauma, have been treated for the most part in the state hospitals in southern Norway. In 1974 Norway was divided into five health regions and the responsibility for an orthopaedic service was imposed on the individual regions.

To make an estimate of the need for orthopaedic beds per 1000 inhabitants in the fifth health region, which is sparsely populated, the mean hospital stay in 1975 for a selected patient material from three surgical departments in the region was recorded. For trauma cases, orthodox orthopaedics and rheumatoid arthritis this was 14.1, 18 and 18.3 days respectively. Based on

these figures the estimate per 1000 inhabitants was assessed as trauma (muscleloscelетal) 0 27 orthodox orthopaedics 0 30 and surgery for rheumatoid arthritis 0 08 The Regional hospital in Tromsø together with one Central hospital have less than half of the beds required Accordingly only after establishment of new orthopaedic services in the other Central hospitals in the region can the patients be given satisfactory service

ANTERIOR DISPLACEMENT OF THE TIBIAL TUBEROSITY IN THE TREATMENT OF CHONDROMALACIA PATELLAE

Einar Sudmann & Berndt Salkowitsch
Regional Hospital in Tromsø Tromsø

The preliminary results of 15 consecutive operations in 13 patients eight men and five women are reported Age range 17 57 years Chondromalacia of the femoral and tibial condyles was found in four knees and in one knee respectively and meniscus tears were found in three The diseased cartilage was removed The mean anterior displacement of the tibial tuberosity was 12 mm

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The preliminary results were assessed as satisfactory and the complications were mainly caused by faulty operative technique

CHRONIC ANTERIOR COMPARTMENT SYNDROME OF THE LEG

Einar Sudmann
Regional Hospital in Tromsø Tromsø

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pa [illegible] syndrome was made by exclusion The paresis responded to blind diathermic fasciotomy
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d a [illegible] patients with ordinary physical exertion The age range was 11–68 years Three patients had paresis and 14 neurological signs of affection of the fibularis profundus nerve The syndrome responded well to blind diathermic fasciotomy in the first 11 consecutive patients operated upon

Most of the patients were females and had been misdiagnosed for years

Oslo, April 16th, 1977

OVERGROWTH OF THE LIMB AFTER FRACTURE OF THE LOWER LEG IN CHILDHOOD

Geir Tangen Øjvind Hansen & Per Edvardsen
Regional Hospital, Trondheim

Eighteen patients treated for leg fracture in childhood were re-examined 8 to 10 years after the injury

The limb length was examined radiologically and the measurements included the tibia the fibula and the femur on both sides A slight overgrowth was found in the tibia The tendency was more marked in oblique fractures and in the youngest children No increase in growth rate was found in the femur or in the fibula

The differences found were small and in most cases without clinical significance

AVULSION OF THE PATELLAR LIGAMENT IN A PATIENT WITH SPASTIC PARAPARESIS

Bjørn Samstad
Regional Hospital Trondheim

An 11 year old girl with spastic paraparesis detected when she was 1 year-old had been able to walk with a walking frame on wheels She had previously had tenotomies of the Achilles tendons because of equinovarus deformities

Following sudden severe pain in both knees she was examined clinically and radiologically On the left side there was an avulsion of the lower pole of the patella and on the right side an avulsion of the patellar ligament from its attachment to the tibial tuberosity The patient also had 25° flexion contractures of both hips

A releasing incision of the origin of the rectus femoris muscle was performed combined with tenotomy of the reflected head of the same muscle bilaterally The patient s complaints disappeared rapidly

FAT EMBOLISM SYNDROME AFTER FRACTURE OF THE TIBIA

Svein Svenningsen
Regional Hospital in Trondheim Trondheim

A 19 year old previously healthy man with an uncomplicated fracture of the tibial shaft lost consciousness two days after the injury He developed tachycardia and anaemia and radiologically bilateral lung infiltrations Despite lack of other signs of hypovolaemia the urinary output was low with signs of renal failure

tein AA is found in higher concentrations in diseases prone to secondary amyloidosis including rheumatoid arthritis However, SAA is also increased in conditions without a predisposition to amyloidosis, quantitation of SAA can therefore not be used in the diagnosis of "risk", or early cases of amyloidosis

Amyloidosis is a serious complication of rheumatoid arthritis However, in many cases the prognosis seems to be better than thought previously Such patients deserve the same, active therapeutic attitude as other rheumatoid patients

HOFFA'S DISEASE

Paul Ferem
Oslo Sanitetsforening Rheumatism Hospital
Oslo

Four women, age 16–25 years, have been treated with excision of the fat pad of the knee joint one bilaterally Three have been relieved of their symptoms while in one the operation was performed too recently to judge the result

The aetiology is discussed, trauma may be the cause Once the condition occurs it seems that the patients enter a "vicious circle", and the treatment of choice is excision of the fat pad Soft tissue X ray, and arthroscopy may be useful in making the diagnosis

ATLANTO AXIAL LUXATION IN RHEUMATOID ARTHRITIS

Jens Teigland
Oslo Sanitetsforening Rheumatism Hospital
Oslo

A videotape was shown of the technique of radiological examination the symptoms and signs and the operative fixation in atlanto axial luxation *ad modum* Brattstrom Granholm

The videotape also dealt with a technique for measuring the spinal fluid pressure with a transducer showing the special pressure pattern elicited by compression of the jugular vein with the head in a neutral position in a ventroflexed and a dorsiflexed position The videotape was produced in the Department of Rheumatoid Surgery in collaboration with the Department of Neurosurgery, Rikshospitalet Oslo

Oslo, February 12th, 1977

CLEIDOCRANIAL DYSOSTOSIS

Tore Gronmark
Telemark Central Hospital, Skien

One case of cleidocranial dysostosis is reported The aetiology, clinical picture and treatment of the lesion are discussed Pseudarthrosis of the clavicle and other clavicular abnormalities in cleidocranial dysostosis usually require no special treatment

AN OPERATIVE TECHNIQUE FOR GENU RECURVATUM

Kåre Hadland
Telemark Central Hospital, Skien

A middle aged woman with marked genu recurvatum, caused by a previous hyperextension injury, was operated on using the following technique

A long strip of the iliotibial band was dissected free, preserving the insertion on the anterior aspect of the tibia The strip was passed obliquely backwards, and pulled through a hole drilled transversely and as far posteriorly as possible through both femoral condyles From here the strip was passed obliquely outside the medial capsule, and under strong tension and with the knee in some degree of flexion, it was anchored on the anteromedial aspect of the tibia

Immobilisation in a plaster cast was maintained for 3 months The result was excellent

SURGICAL TREATMENT OF DISLOCATION OF THE PERONEAL TENDONS

Tore Gronmark
Telemark Central Hospital Skien

One case of dislocation of the peroneal tendons treated operatively by the method of Ellis Jones is reported Early operation for dislocation of the peroneal tendons is advocated

Oslo, March 12th, 1977

ORTHOPAEDICS IN A REGIONALIZED HEALTH SERVICE SYSTEM HEALTH REGION 5

Einar Sudmann
Regional Hospital in Tromso Tromso

In Norway orthopaedic patients except those with acute trauma have been treated for the most part in the state hospitals in southern Norway In 1974 Norway was divided into five health regions and the responsibility for an orthopaedic service was imposed on the individual regions

To make an estimate of the need for orthopaedic beds per 1000 inhabitants in the fifth health region which is sparsely populated the mean hospital stay in 1975 for a selected patient material from three surgical departments in the region was recorded For trauma cases orthodox orthopaedics and rheumatoid arthritis this was 14 1 18 and 18 3 days respectively Based on

these figures the estimate per 1000 inhabitants as assessed as trauma (musclelosceletal) 0 27 orthodox orthopaedics 0 30 and surgery for rheumatoid arthritis 0 08 The Regional hospital in Tromsø together with one Central hospital have less than half of the beds required Accordingly only after establishment of new orthopaedic services in the other Central hospitals in the region can the patients be given satisfactory service

ANTERIOR DISPLACEMENT OF THE TIBIAL TUBEROSITY IN THE TREATMENT OF CHONDROMALACIA PATELLAE

Einar Sudmann & Berndt Salkowitsch
Regional Hospital in Tromsø Tromsø

The preliminary results of 15 consecutive operations in 13 patients, eight men and five women are reported Age range 17–57 years Chondromalacia of the femoral and tibial condyles was found in four knees and in one knee respectively and meniscus tears were found in three The diseased cartilage was removed The mean anterior displacement of the tibial tuberosity was 12 mm

Ten of the patients were improved, three of them resumed athletic activity One patient was not improved and in two the observation time was too short

Postoperative infection occurred in one case and thrombosis of the leg in one The anterior displacement failed in one and one patient broke his leg in the operated diaphysis in a skiing accident

The preliminary results were assessed as satisfactory and the complications were mainly caused by faulty operative technique

CHRONIC ANTERIOR COMPARTMENT SYNDROME *OF THE LEG*

Einar Sudmann
Regional Hospital in Tromsø Tromsø

In a patient suffering from backache and paresis of the muscles of the anterior compartment of the leg the diagnosis of chronic anterior compartment syndrome was made by exclusion The paresis responded to blind diathermic fasciotomy

During the following 10 months this condition was especially looked for in patients with painful legs Unexpectedly a similar syndrome was diagnosed in 23 patients with ordinary physical exertion The age range was 11–68 years Three patients had paresis and 14 neurological signs of affection of the fibularis profundus nerve The syndrome responded well to blind diathermic fasciotomy in the first 11 consecutive patients operated upon

Most of the patients were females, and had been misdiagnosed for years

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A 69 year old previously healthy man with an uncomplicated fracture of the tibial shaft, lost consciousness two days after the injury He developed tachycardia and anaemia and radiologically bilateral lung infiltrations Despite lack of other signs of hypovolaemia the urinary output was low with signs of renal failure

Clinical pulmonary signs were scanty The patient died 5 days after injury

Autopsy revealed multiple fat emboli in the lungs and brain and small haemorrhagic infarcts in all parts of the brain Fat embolism syndrome after a tibial fracture is rare and especially so in this age group

AVULSION OF THE ISCHIAL TUBEROSITY

Anders Dahle
Regional Hospital in Trondheim Trondheim

Four patients with avulsion of the ischial tuberosity two boys and two girls are reported The main symptom was pain in the buttock which started at the age of 12 to 15 years Three had been injured during sports activities and in one patient the symptoms occurred after rowing without other trauma The mechanism of the pain could in all patients be explained as overstretching of the hamstrings

Two patients with complaints lasting 3 and 7 years respectively were operated upon They had a non union of the apophysis which was removed with good results

Stavanger, May 12th–14th, 1977

EXPERIENCES WITH A STERILE OPERATING CHAMBER

Sverre Sleie
Sandnes Hospital Sandnes

In September 1974 a sterile operating chamber was installed at this hospital Up to November 1976 324 total hip replacement operations *ad modum* Charnley were performed in the chamber So far there have not been any primary or secondary signs of infection or loosening of the prostheses

The sterile operating chamber has furthermore been in daily use for other types of bone operations

At each operation two Petri dishes of blood agar have been placed on the floor of the chamber For 1140 observations the growth has been 0 6 colonies per dish per hour

DOES INDOMETHACIN (IMC) PREVENT POSTOPERATIVE ECTOPIC OSSIFICATION IN TOTAL HIP REPLACEMENT ?

Kare Almdsbakk & Per Røysland
Regional Hospital in Trondheim Trondheim

Eighty one operated hips in 73 patients were evaluated 3 months after operation There were two main groups 54 hips in patients not given IMC and 27 hips in patients given 25 mg IMC, 3 times daily the first 4 weeks postoperatively

The group without IMC showed a greater frequency of high grade ossification while low grade ossification was equally frequent in the two groups In the former group there were no signs of ectopic ossification in only 14 hips i e 26 per cent In comparison no ossification was seen in 17 hips in patients given IMC i e 63 per cent

It is concluded that IMC significantly prevents postoperative ectopic ossification following total hip replacement

INDOMETHACIN HIPS

Helge Rønningen & Kortald Langeland
Sophies Minde Orthopaedic Hospital Oslo

The course of osteoarthritis in 294 hips of 186 patients was evaluated by examining their radiographs The development of the disease in patients treated with indomethacin was compared with that in a control group In the indomethacin group the disease progressed more frequently and in some parameters the progress seemed more severe The results support previous reports indicating that indomethacin might have a deleterious effect on osteoarthritic hip joints Some possible explanations for this adverse effect of indomethacin treatment are briefly discussed

CONTROLLED INDUCED HYPOTENSION IN HIP SURGERY

M A Khalid Kahn & Ole Dankert Lunde
Sandnes Hospital Sandnes

The pharmacological basis the technique the indications and contraindications for the use of induced controlled hypotension were given Fifty patients had a total hip replacement arthroplasty *ad modum* Charnley 25 under controlled hypotension 25 under normotension

In the former group the peroperative haemorrhage was reduced to a fifth compared with the normotension group the operative time was reduced by 15 per cent and the need for blood transfusions reduced by 50 per cent A comparative study of nine bilateral cases gave identical results There were no postoperative complications recorded in either of the groups

FRACTURE OF THE FEMORAL STEM AFTER TOTAL HIP REPLACEMENT

Pål Benum
Regional Hospital in Trondheim Trondheim

Three cases of fractured femoral stems of the Charnley Müller prosthesis are reported in males younger than 70 years at implantation on average 4 years and 3 months after operation Out of 74 prostheses with a minimum observation period of a corresponding length 14 had been implanted in males under 70 years of age

Resorption of the calcar femoris preceded fracture of the stem All the fractured stems had been implanted in a varus position. Tissue reaction to wear products might have contributed to bone resorption

Even if a new design may reduce the tendency to fracture of the stem of the prosthesis, it is emphasized that varus position of the stem should be avoided

LATE INFECTIONS AFTER TOTAL HIP REPLACEMENT

Olav Reikerås
Kronprinsesse Marthas Institute, Oslo

Infection is the most serious complication of total hip replacement We have reviewed 293 operations with a mean follow up of 4 2 years There were five infections 1-4 years after the operation Three of these were the low virulent type combined with loosening of the prosthesis and the presence of staphylococcus albus Two young patients 29 and 33 years respectively, with Bechterew s disease got a virulent infection 2 and 3 years after the operation One was infected with β haemolytic streptococcus following an erysipelas of the leg The other was infected with staphylococcus aureus in connection with extraction of a molar tooth. It is suggested that both were infected from haematogenous seeding

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Tor Steinar Raugstad Anders Mølster Willy Haukeland & Antti Alho
Haukeland Hospital Bergen

The Ender method consists of insertion of round flexible condylocephalic intramedullary nails 104 patients were reviewed The median age was 77 years and 80 per cent were older than 70 years Concomitant diseases were found in 73 per cent

The follow up showed good functional results There was a tendency for shortening to occur more than 2 cm in 15 per cent of the patients External malrotation of more than 20° was observed in 15 per cent of the patients. Towards the end of the series, with awareness of this problem the malrotation decreased

The Ender method has advantages, with a short operation time minor operative trauma, and early mobilization and weight bearing Because of some rotational instability the method should be reserved for patients older than 65-70 years

FRACTURES OF THE NECK OF THE FEMUR TREATED WITH VON BAHR SCREWS

Anders Mølster, Odd Søreide & Tor Steinar Raugstad
Haukeland Hospital, Bergen

The material consists of 103 patients with displaced, intracapsular fractures of the neck of the femur treated with von Bahr screws Early weight bearing was allowed

At the 1-year follow-up, 18 patients had mechanical failure, 68 were healed with six diagnosed aseptic necroses of the head of the femur Eleven patients were dead, and the remaining did not attend the follow up examination Excellent or good results were achieved in 80 per cent in the healed fracture group (Stinchfield classification system)

There was a highly significant correlation between operative result and late result Exact reduction and a slight valgus position, as well as a parallel screw position, with the distal screw lying on the calcar, led to favourable late results The degree of primary dislocation (Garden 2–4) did not correlate with the incidence of delayed healing or mechanical failure The number of cases with aseptic necrosis was small, but five of the six had primary dislocation graded as Garden 4, though all six had an operative result graded as excellent or good

OPERATIVE TREATMENT OF COMMINUTED FRACTURES OF THE LOWER END OF THE HUMERUS

Pål Benum & Svenn Syversen
Ullevål Hospital, Oslo

The results after osteosynthesis of 12 severely dislocated comminuted fractures, stabilized with screws, pins and/or plates, are reported The transolecraneal approach was used in 10 patients Flexion was excellent in three, good in four, and fair in three patients One suffered from pain after healing of the fracture. Two patients, operated with an inverted V incision through the triceps aponeurosis dislocated and ended up with poor mobility

It is concluded that exact reduction and stable fixation of highly dislocated, comminuted fractures of the lower end of the humerus should be performed with a transolecraneal approach However excellent operative conditions are mandatory

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COMMINUTED FRACTURES IN THE DISTAL PART OF THE RADIUS TREATED WITH EXTERNAL FIXATION AD MODUM HOFFMANN

Ulf Slungaard
Aker Hospital Oslo

Comminuted fractures of the distal end of the radius have a tendency to heal with shortening when treated with reduction and plaster cast

Five patients treated with external fixation ad modum Hoffman with two screws in the second metacarpal bone and two screws in the radius proximal to the fracture are reported

The patients tolerated this treatment well finding it more comfortable than plaster (all had been first unsuccessfully treated with plaster)

SPIRAL FRACTURES OF THE TIBIA TREATED WITH PERCUTANEOUS WIRE CERCLAGE

Anders Mølster
Haukeland Hospital Bergen

The preliminary results of Goetze s percutaneous application of wire cerclage followed by *functional plaster for oblique and spiral fractures* of the tibia are reported

Seven patients were operated on and an exact anatomical position was achieved without primary complications None redislocated and so far four have been allowed weight bearing after 10–16 weeks The wires were removed after 12 23 weeks

Percutaneous cerclage makes plaster treatment easier and safer without a tendency for shortening to occur and permits early ambulation It *should only be used for fractures with a frac*ture line longer than two tibia diameters

RECONSTRUCTION OF THE LATERAL LIGAMENTS OF THE ANKLE JOINT AD MODUM STØREN

Tor Finn Denstad & Ludvig Fjeld Solheim
Martina Hansens Hospital Sandvika

Reconstruction of the lateral ankle ligaments *ad modum Støren using the medial one third of* the Achilles tendon as a nourished transplant is probably *little known* [*Acta chir scand* (1959) 117 501–509]

Eighteen patients previously operated on using this *technique* answered a questionnaire Seventeen had a stable joint and were satisfied Due to a new injury one was reoperated using Evan s tenodesis *operation Active* athletes were in full training 3–4 months after the operation Late residual symptoms (pain reduced mobility swelling) were few

REPAIR OF RUPTURES OF THE CUFF OF THE SHOULDER JOINT USING A POSTERO SUPERIOR ACROMION SPLITTING APPROACH

Einar Sudmann
Regional Hospital in Tromsø Tromsø

Two patients with complete rupture of the shoulder cuff have been operated on using a postero superior approach *ad modum* Debeyre et al [*J Bone Jt Surg (1965)* 47 B 36–42] *The ap*proach proved very adequate permitting easy mobilization of the supraspinatus muscle in one case and making the repair of the tear possible without undue tension

AN EVALUATION OF THE PROSTHESIS SERVICE FOR LOWER EXTREMITY AMPUTEES IN SANDNES

Else Marie Høyem
Sandnes Hospital Sandnes

A follow up examination of 82 patients (average age 60½ years) fitted with a prosthesis showed that a surprisingly large number of the patients (95 per cent) were using their prosthesis but 62 per cent of them had more or less serious problems now and then Half of the patients were not satisfied with the service provided

Indications for amputation were vascular diseases in 34 injuries in 31 and other causes in 17

It is concluded that it is necessary to provide more adequate information for patients and relatives more time should be spent for fitting and rehabilitation there should be more frequent *visits from the* orthopaedic technician and a regular follow up of the amputees Treatment at rehabilitation centres would be preferable

GIANT CELL TUMOUR OF BONE TREATED WITH AUTOGENOUS BONE GRAFT

Terje Terjesen
Regional Hospital Trondheim

Most giant-cell tumours of bone are invasive and aggressive in their behaviour with a recurrence rate in large series of about 40 per cent A 30 year old woman with a giant cell tumour in the distal end of the radius was *treated by en bloc* resection and reconstructed with an autogenous bone graft from the upper *third of* the fibula

Solid union between the graft and the radius occurred The functional result was satisfactory She had no pain in the wrist and a good grip although *the range of mobility* in the wrist

joint and rotation of the forearm was considerably reduced

GRISEL'S SYNDROME
Kjell Harbo
Sandnes Hospital Sandnes

Two girls 4 and 7 years of age respectively developed painful torticollis the youngest after an upper respiratory tract infection and the oldest after an operation for cleft lip and palate

Radiological examination showed in the youngest patient a subluxation between C-II and C-III and in the other, an atlantoaxial subluxation.

Both patients were treated by the double mattress technique" for 4 and 8 weeks and were further immobilized in a Minerva jacket for 8 and 12 weeks respectively The subluxation was reduced in both cases during extension treatment Both girls have completely recovered The treatment started in one case 1 month, in the other 6 months after the onset of symptoms

RESTORATION OF THUMB OPPOSITION
Gisle Uppheim
Kronprinsesse Marthas Institute Oslo

A total of 110 tendon transfers for restoration of thumb opposition were reviewed (sequelae to poliomyelitis 66 trauma 30) The results were good in 74 fair in 25 and poor in 11 cases The higher proportion of failures in the poliomyelitis group can be explained by the use of muscles which were too weak.

Distal insertion *ad modum* Bunnell (18 cases) gave a better result than did insertion *ad modum* Riordan (60 cases) Of eight extensor muscle transfers six had a good result Of 97 flexor sublimus transfers 23 developed a significant flexion contracture at the proximal interphalangeal joint of the donor finger while three developed a swan neck deformity

OPERATIVE TREATMENT FOR POST TRAUMATIC STIFFNESS OF THE KNEE JOINT
Per Siewers & Helge Fjermeros
Central Hospital in Kristiansand
Kristiansand S

Five adult patients who had severe stiffness of the knee joint following trauma, in or near the joint were treated by operation when no further spontaneous improvement was expected

The operative procedures were based mainly on Thompson's quadricepsplasty The average gain in active flexion was 60° a highly satisfactory result.

WAGNER'S METHOD OF LIMB LENGTHENING
I Bjerkreim N Langeland & H Ronningen
Sophies Minde Orthopaedic Hospital Oslo

A short survey of indications for and complications in leg lengthening was given The Wagner device for limb lengthening was used in a 14 year old girl height 150 cm with a congenital 6 cm shortening of the left femur After 3 weeks of distraction the pins had bent slightly and a varus angulation developed Equalisation was predicted at 6 weeks The proximal pin holder however slipped on the distraction bar and half of the correction was lost After adjustment and resecuring of the pin holder limb length equalisation was attained at 12 weeks Osteosynthesis using a strong metal plate and cancellous bone from the iliac crest was performed The varus angulation could be corrected and the Wagner device was used as additional fixation for another 4 weeks Because of considerable reduction in knee flexion to 30° the pins were removed and the knee flexion rapidly normalized

A follow up radiological examination showed increasing bone healing

LENGTHENING OF THE FEMUR AD MODUM WAGNER
Einar Sudmann
Regional Hospital in Tromsø Tromsø

In a female patient aged 17 years with a leg *length discrepancy* of 7 5 cm the femur was lengthened 7 5 cm in 0 15 cm daily increments after a transverse mid femoral osteotomy The length so obtained was retained by *a plate applied* laterally and blocks of bone allografts *wedged* in between the bone ends The patient with the Wagner lengthening device attached was allowed out of bed on crutches No complications were encountered

NON UNION OF THE CLAVICLE
Arvid Hegberg
Sandnes Hospital Sandnes

Factors predisposing to development *of post* traumatic non union of the clavicle and *indications* for operative treatment were discussed Four patients treated with intramedullary *nailing using Rush* pins and transplantation of *bone chips* from the iliac crest were *reported The results* were good

THE USE OF BONE CEMENT FOR FIXATION OF FRACTURES IN PATIENTS WITH MYELOMATOSIS

Bjorn Samstad
Regional Hospital Trondheim

Bone cement was used for fixation of fractures in two patients with myelomatosis. In an 80 year old woman with a spontaneous fracture of the femur which crossed the lesser trochanter the entire medulla of the proximal fragment was filled with bone cement prior to fixation of the fracture with an angled nail plate. There were no postoperative complications and the patient walks without support.

In a 56 year old man a spontaneous fracture of the acetabulum was treated with insertion of a Muller total hip prosthesis. The bone defect was filled with bone cement prior to the insertion. There were no postoperative complications. Four months later he was admitted with an identical fracture of the other hip which was treated in exactly the same way with a similar satisfactory result.

There have been no clinical or radiological signs of recurrence of the local process 1 year postoperatively in either patient.

Acta orthop scand 48 561–565 1977

ELECTRICAL STIMULATION IN DELAYED UNION OF LONG BONES

K P SRIVASTAVA & A K SAXENA

SN Medical College Agra India

The role of electricity in the promotion of fracture union of long bones in human beings requires further investigation An electric stimulator was devised through which 15 μA current was applied to the fractured long bones of 20 patients with delayed union The best results were obtained in cases where the negative electrode was introduced at the fracture site and the positive electrode was placed proximal to the fracture area In 90 per cent of cases treated by different methods in this series union occurred within an average period of 9¼ weeks The rate of infection following introduction of the electrodes for electrical stimulation was 20 per cent

Key words delayed union electrical stimulation human beings

Accepted 20 vii 77

Friedenberg & Brighton (1966) measured the resting potentials of fractured bone in rabbits They found that the metaphysis had a negative potential in relation to the diaphysis Following fracture of the shaft of the tibia, the diaphysis became negative in relation to the epiphysis and the metaphyseal potential also became more negative The negativity of the diaphysis remained until the fracture united after which the potential returned to normal

Bassett et al (1964) implanted iridium electrodes on dog femurs and observed the formation of extensive callus at the cathode within a period of 15 days using a 10 100 μA current An increased number of young mesenchymal cells and osteoblasts were found around the cathode At the positive electrode a brownish material consisting of denatured protein was found

Brighton & Alfred (1972) attributed the increased callus formation to the increased alkalinity and the low oxygen tension in the cathode area He observed that the oxygen tension remained low during the phases of healing and later returned to normal when the fragments consolidated Low oxygen tension led to calcium release from the mitochondria of cartilage cells and it initiated the pluripotential cells to differentiate into osteoblasts and chondroblasts

Friedenberg et al (1970) found that a 20 μA was the optimum strength of the current Bone destruction occurred when the current was raised to 40 50 μA Cieszynski (1963) observed that a positive potential increased the breaking strength of rabbit bone, while a negative potential did not improve healing Friedenberg (1971 a) and Lavine et al (1971) reduced the period of immobilization of fractures in rabbits by electrical stimulation

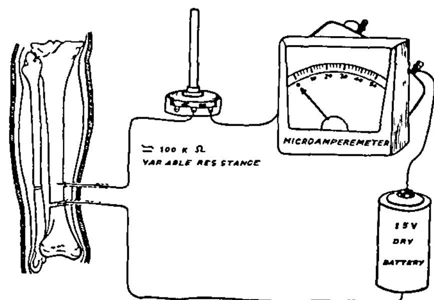


Figure 1 Diagram of the electrical circuit for electrical stimulation of bone

Even in human beings electrical stimulation has been used successfully Friedenberg (1971 b) achieved union in a case of non-union of the medial malleolus Levine et al (1972) reported union in a case of congenital pseudarthrosis of the tibia Jorgensen (1972) has published the largest series having employed electrical stimulation in 24 cases of tibial fractures He used a direct current of 20–100 μA in addition to alternating current and found that the consolidation time was reduced by 30 per cent Soft tissue necrosis and infection occurred at the anode in a few cases

METHODS

Stimulator The electrodes were made from 28 gauge stainless steel wire insulated with polythene tube which was sealed over the wire the ends being left bare A trephine and cannula were used for inserting the electrodes

The circuit was made up of 28 gauge insulated copper wire 1 5 V dry battery 0 100 k Ω variable resistance (used in radio sets as a volume regulator) microampere meter with a scale of 0 50 μA

The variable resistance and the microampere meter were connected in series with the positive end of the battery while the negative end was connected directly to the electrode using 28 gauge insulated copper wire (Figure 1) The whole of the circuit except the microampere



Figure 2 Microampere meter connected to the electrical circuit placed inside the plaster

meter was fixed to the plaster (Figure 2) The microampere meter was used to check the strength of current flowing in the circuit The current strength was kept constant by altering the resistance during the periodical checkups

PATIENTS

In the present series 20 cases of delayed union were studied and followed up (Table 1)

Table 1 Electrical stimulation in 20 cases of delayed union

Bone	No of patients	Percentage
Tibia	16	80
Humerus	1	5
Radius and ulna	3	15

All the patients had pain elicited by bending stress near the fracture site and 12 of them had slight mobility of the fragments Only cases of delayed union with a minimum of 5 months duration and with no radiological evidence of established non union were included in the series (Table 2)

Table 2 Interval between the time of injury and the beginning of electrical stimulation

Interval (months)	No of patients	Percentage
Up to 5	6	30
5–10	10	50
11 15	2	10
16–20	nil	—
Above 20	2	10

Four patients had a mild infection before starting the electrical stimulation

RESULTS

The patients were divided into three groups (Table 3 and Figure 3) 15 μA current was given in each case The preliminary assessment was made after 8 weeks of electrical stimulation

Group A In all four patients the electrodes were placed with one proximal and one distal to the fracture site All united in the course of 8 to 12 weeks

Group B In this group, the positive electrodes were inserted proximal to the fracture site and the negative electrodes were inserted at the fracture site Out of 12 patients treated in this group, 10 united within 8 weeks In one, the electrodes were removed too early as a result of which the plaster immobilization had to be prolonged for another 4 weeks increasing the healing time to 12 weeks The remaining fracture did not unite because the patient started weight-bearing too early Bone grafting had to be performed in this case

Group C In four patients of this group the negative electrodes were inserted at the fracture site while the positive electrodes were left in the adjacent soft tissues One united within 8 weeks, two needed further stimulation for 2½ weeks and one failed to unite due to gross infection

Out of a total of 20 cases, 18 united within an average period of 9¼ weeks of electrical stimulation, while two cases failed to unite

The period of hospital stay was 3 30 days in 18 cases Two cases had to stay for longer periods due to infection

Complications

Infection Out of 20 cases, four became infected One of these failed to unite due to the infection

Loosening of electrodes In four cases the electrodes were pulled out while dressings were being changed, they were re inserted

Metallic corrosion of electrodes The corrosion occurred at the anode, leading to longitudinal splitting and occasional breaking of the wire

In a few cases the uninsulated part of the wire turned black

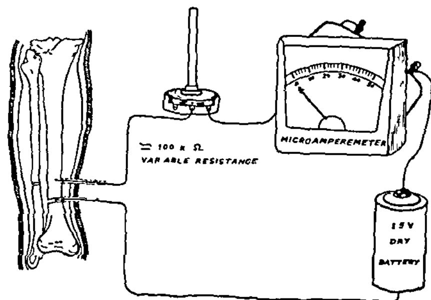


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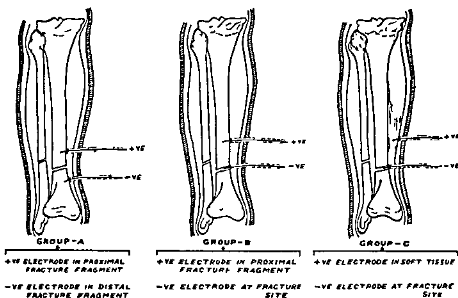


Figure 3 Diagram showing the placement of the electrodes in the three groups (A, B C)

Table 3 Results of electrical stimulation

Group	No of cases	Average strength of current (μA)	Duration of electrical stimulation (weeks)	Results		
				Radiological union in 8 weeks	Radiological union in 12 weeks	No union within 12 weeks
A	4	15	8	–	4	–
B	12	15	8	10	1	1
C	4	15	8	1	2	1

DISCUSSION

The present study was based on clinical as well as radiological findings It demonstrates that union may result from electrical stimulation in otherwise indolent cases of delayed union The negative potentials were induced in a relatively inactive area at the site of delayed union in order to cause acceleration of cellular activity In 90 per cent (18/20) of the cases treated in the various groups in this series union was achieved in an average period of 9¼ weeks

Union in group A cases in this series confirmed the findings of Lavine et al (1972) and Jorgensen (1972) but at the same time contradicted the findings of Friedenberg (1971 b), who failed to obtain acceleration of union in patients comparable with those in group A of this series This discrepancy of results could be due to the short period of electrical stimulation used in the cases described by Friedenberg Although union was obtained in all group A cases of this series, it took a longer time (12 weeks) than in B and C groups (8 weeks)

Results were found to be better in cases, where the cathode was placed at the fracture site (groups B and C) Best results were observed in group B, where the positive electrode was inserted proximal to the fracture site and the negative at the fracture site itself This is in agreement with the findings of Friedenberg The strength of current used in this

series (15 μA) in all cases gave satisfactory union with no unfavourable effects on bone substance

The infection rate in this series was 20 per cent (4/20) Two of these were superficial Osteoporosis of the distal tibial fragment as reported by Jorgensen (1972) was not seen in this series The feeling of warmth at the site of introduction of the electrodes was noted in a few cases in the initial stages

Conclusions

1 Negative potentials can promote the union of fractures in cases of delayed union

2 In 90 per cent of cases treated by various stimulation methods union occurred in an average period of 9¼ weeks

3 The best results were obtained when the negative electrodes were placed at the fracture site and the positive electrodes in the proximal fragment

4 The morbidity and hospitalization period was considerably reduced

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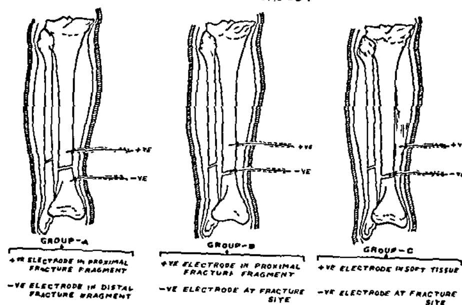


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It might, therefore, be of value to have an easy and reproducible method for counting osteoclasts per surface area of bone The determination of active and inactive resorption surfaces and bone formation surfaces used earlier is more difficult and perhaps not so useful when testing the hypotheses mentioned Data in the literature concerning the normal number of osteoclasts are sparce and vary greatly and the number has been decided per area of the section (e g , Bordier & Tunchot 1972, 0 37/mm², and Ellis & Peart 1973, 0 01 0 03/mm²) In this paper we have tested a modified method for counting osteoclasts both per area of section and per surface of bone area in *normal* individuals compared with patients with osteoporosis and patients with chronic nephropathy undergoing haemodialysis

MATERIAL AND METHODS

The control group consisted of 51 men and 36 women (10–90 years) who had died suddenly *following* cardiac arrest accident or suicide and had been brought to the Forensic Department for autopsy A wedge-shaped *sample was taken from* the iliac crest just dorsal to the iliac spine

The osteoporosis group consisted of 48 women 44–71 years) with radiological and clinical signs of spinal osteoporosis The nephropathic group consisted of 91 patients all of them undergoing haemodialysis Details of the nephropathic patients with data relating to the state of the disease and laboratory examinations will be *presented in* another paper In the present paper we have only used the biopsies for testing the osteoclast counting method

A 15 × 3 mm cylindrical sample was obtained from the patients with a motor-driven slow moving drill according to Burckart The sample was taken vertically about one cm dorsal to the iliac spine

The samples were fixed in formalin dehydrated in alcohol chloroform and embedded in methylmethacrylate without previous decalcification and finally cut into sections (4 7 μ) *The* sections were stained according to Goldner (1938

The margins of the sections were taped in order to obtain a straight line [illegible] rectangular area of *trabecular bone* All osteoclasts in this area were counted (per mm²) with 40 × objective and 10 × eyepiece magnification The osteoclasts were identified by their light pink, often vacuolar, cytoplasm and the distinct nucleoli Only osteoclasts with two or more nuclei and in contact with the bone surface were counted

In our evaluations of trabecular and osteoid surfaces we used an objective magnification of 13 × and an eyepiece magnification of 10 × We used a grid with wave formed lines in the eyepiece as described by Schenk et al (1969) We counted the number of intersections between the grid lines and trabecular and osteoid surfaces in 25–30 fields of every specimen In order to make the whole procedure simpler we counted only the number of intersections without calculating the trabecular circumference area as in Schenk et al (1969) This latter calculation does not give any further useful information beyond the counted data and our main interest is to present the number of osteoclasts relative to the remaining bone tissue which can be used to compare groups of specimens with each other

RESULTS

The number of osteoclasts per section area and the number relative to the bone surface area in normal individuals, in osteoporotics and in haemodialysis patients are seen in Table 1 The mean of the absolute and the relative number of osteoclasts is the same in normal and osteoporotic individuals, in haemodialysis patients almost ten times *higher The* frequency distribution of osteoclasts per mm² section in per cent of the total number of normal individuals, osteoporotics and haemodialysis patients, respectively, is shown in Figure 1 It seems clear that 99 per cent of the normal individuals have between 0 0 1 osteoclasts *per mm*² section Most (or 90 per cent) of the osteoporotic *patients have* the same average number of osteoclasts as normal individuals but there is also a small group with between 0 1–0 2 osteoclasts It is remarkable that so many of the osteoporotic patients (30 per cent) have no osteoclasts at all [illegible] tients [illegible]

In [illegible]

the osteoclast count/mm² decreased sig-

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OSTEOCLAST COUNTING IN CRISTA BIOPSIES

O JOHNELL, P-E WIKLUND & A HULTH

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(University of Lund), Malmo Sweden

A description is given of a modified method of counting osteoclasts *both per section area and also relative to the remaining trabeculae* surface area in crista biopsies The material consisted of normal individuals, patients with clinical osteoporosis, and patients with chronic renal failure undergoing haemodialysis *The number* of osteoclasts in the biopsies from normal and osteoporotic individuals showed a normal distribution with the same mean In the haemodialysis patients there was a marked skew distribution In normal individuals, there was a significant decrease in the number of osteoclasts per section area with age, but this was not significant when calculated relative to the bone surface area

Key words crista biopsies, osteoclasts, osteoporosis, haemodialysis, renal osteopathy

Accepted 10 vi 77

When looking through histological slides from crista biopsies of older normal or osteoporotic humans, an almost total ab*sence of osteoclasts (and osteoblasts) is* apparent Therefore, it is difficult to explain how the bone tissue can disappear with increasing age, especially in postclimacteric women The periosteocytic resorption described by Belanger (1971) cannot be valid in "idiopathic" osteoporosis since the remaining bone trabeculae always have normal bone density Jaffe (1972), among others considers therefore that the osteoclasts do not have an exclusive significance in the development of osteoporosis

Until the opposite is proven, however, there is reason to consider osteoclasts as *being responsible for bone resorption* also in the development of osteoporosis It is possible that osteoporosis develops *very rapidly, mainly in the initial* period after menopause, or that some types of osteoporoses proceed stepwise by repeated osteoclast attacks over short periods In fact, during the last few years some substances producing osteoclastic resorption of bone have been investigated, e g, OAF (osteoclast activating factor), produced *in vitro* by mitogenic stimulation of lymphocytes (Horton et al 1972) and prostaglandins (Dietrich & Raisz 1975), active, for example, in connection with immune response and inflammatory disease (and malignancy) These and perhaps other substances with similar effect, working over short periods, could explain the apparent defective connection between bone resorption and acting cells

Financial support was *obtained from* Herman Järnhardts Stiftelse and the Swedish Medical Research Council

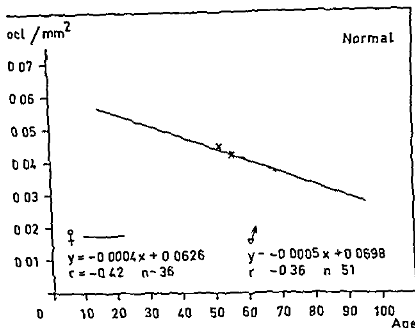


Figure 2 The relation between the number of osteoclasts per mm² section and the age of normal individuals There is a significant correlation in both sexes The correlation coefficient for both sexes r — 0 32

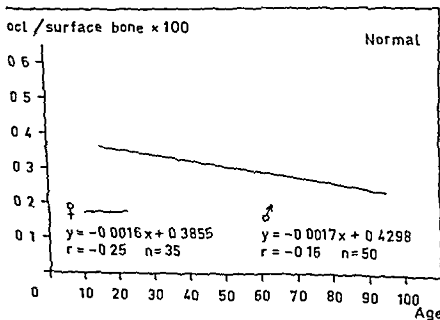


Figure 3 The relation between the number of osteoclasts per surface bone and the age of the normal individuals There is no longer any significant correlation

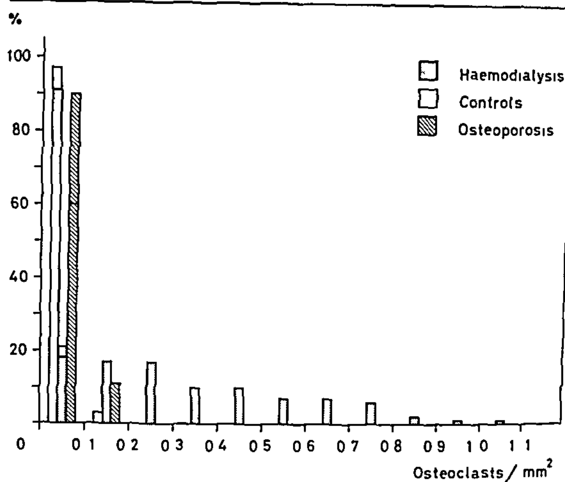


Figure 1 Histogram showing the frequency distribution of the number of osteoclasts/mm² as a percentage of the total number of normal individuals and patients with osteoporosis or haemodialysis The detached upper parts of the three staples in the 0 0 1 area represent cases without osteoclasts

Table 1 The number of osteoclasts per mm² of the section and the number of osteoclasts relative to the bone surface area in the total material The correlation coefficients for the number of osteoclasts relating to age are also shown

		Osteoclasts/mm² section		Osteoclasts relative to bone surf area	
		Mean and SD	*Age regression*	*Mean and SD*	*Age regression*
Normal	$n = 87$	0 04 ± 0 02	r = —0 32**	0 003 ± 0 001	r = —0 19
Osteoporosis	$n = 48$	0 04 ± 0 04	r = —0 19	0 003 ± 0 003	r = —0 23
Haemodialysis	$n = 91$	0 32 ± 0 26	r = —0 37**	0 024 ± 0 014	r = —0 27*

** = 0 01 > P > 0 001 * = 0 05 > P > 0 01

nificantly with age See Table 1 and Figure 2 (normal individuals) There was no difference between men and women However, when the osteoclast numbers were divided by the relative bone surface area, the age decrease was no longer significant for normal individuals, but there was a low significance for the haemodialysis group See Table 1 and Figure 3 (normal individuals) The correlation between the number of osteoclasts/mm² and the relative bone surface

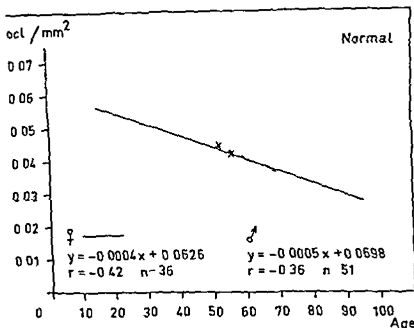
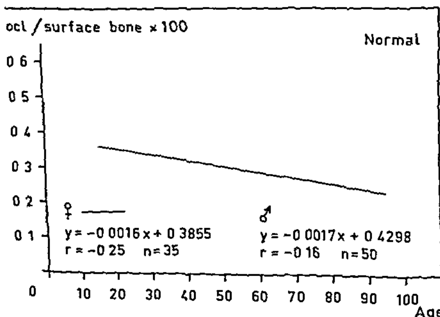


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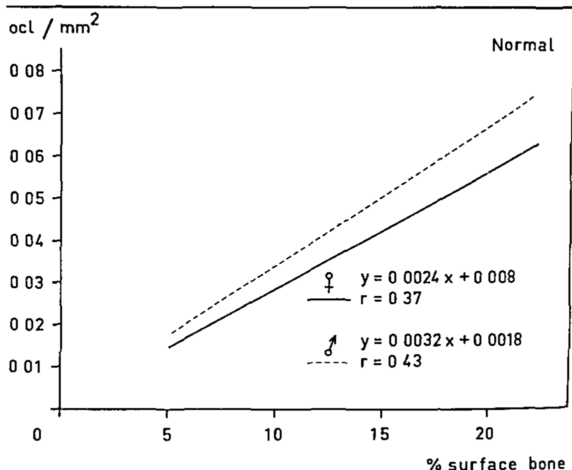


Figure 4 The correlation between the number of osteoclasts counted per mm² section of the slides and the percentage surface area of bone There is a significant correlation

area in normal (Figure 4) and dialysis cases was significant There was, however, no correlation between osteoid surface and the number of osteoclasts/mm²

DISCUSSION

A method for counting osteoclasts in the iliac crest is described which differs only slightly from previous methods The average number of osteoclasts is very low in sections from normal and osteoporotic iliac crests, and lower than that presented by Bordier & Tunchot (1972) The average osteoclast number in patients undergoing haemodialysis was almost ten times higher, but the frequency distribution, unlike normal and osteoporotic individuals, is quite skew—perhaps indicating different degrees of severity of the disease

This difference between our normal values and those of Bordier & Tunchot might be due to our not having counted osteoclasts with only one nucleus, either actual uni-nuclear or multinuclear cells cut through one pole Our way of counting is easier and certainly more reproducible It is not greatly dependent on the quality of staining

In the normal group we found a decreasing osteoclast count/mm² of the section with age and no difference between men and women This decrease is not actual, being due to decreased bone surface, which was also found by Schenk et al (1969) In five cases in the osteoporosis group, we found a large number of osteoclasts (0 1 0 2/mm²), out of

keeping with the rest of the group Most of these osteoclasts were lying close to the surface of the trabeculae without Howships lacunae We have no information as to whether these patients were suffering from some illness Thus, we have no explanation for this finding other than it might possibly involve cases where the bone tissue was exposed to an incipient osteoclastic attack

There was no correlation between the number of osteoclasts and the osteoid surface which supports the hypothesis that osteoclasts resorb the bone tissue intermittently

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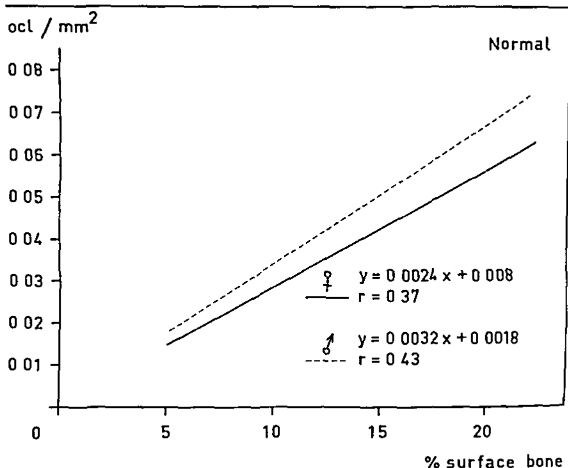


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A method for counting osteoclasts in the iliac crest is described which differs only slightly from previous methods The average number of osteoclasts is very low in sections from normal and osteoporotic iliac crests, and lower than that presented by Bordier & Tunchot (1972) The average osteoclast number in patients undergoing haemodialysis was almost ten times higher, but the frequency distribution, unlike normal and osteoporotic individuals, is quite skew—perhaps indicating different degrees of severity of the disease

This difference between our normal values and those of Bordier & Tunchot might be due to our not having counted osteoclasts with only one nucleus, either actual uni-nuclear or multinuclear cells cut through one pole Our way of counting is easier and certainly more reproducible It is not greatly dependent on the quality of staining

In the normal group we found a decreasing osteoclast count/mm² of the section with age and no difference between men and women This decrease is not actual, being due to decreased bone surface, which was also found by Schenk et al (1969) In five cases in the osteoporosis group, we found a large number of osteoclasts (0 1 0 2/mm²), out of

Table 1 Types of implant used

Source of bone and treatment	Method of wash	Whether with marrow
Marrow free iliac cancellous, non decalcified	0 1 M NaH_2PO_4	With and without
	70 % ethanol	With and without
	0 9 % NaCl	With and without
Marrow free, iliac cancellous decalcified in 0 6 N HCl	0 1 M NaH_2PO_4	With and without
	70 % ethanol	With and without
	0 9 % NaCl	With and without
Nil	Nil	Marrow alone

MATERIAL AND METHODS

The experimental design used was similar to that employed previously for evaluating the effect of impregnating fresh and treated allo grafts of cancellous bone with autologous red marrow (Burwell 1964 1966 Nade & Burwell 1977)

The donor bone and methods of treatment

Bone for implantation was taken from both ilia of recently killed rabbits under sterile con ditions The outer cortex was removed and bone marrow was dislodged from the inter trabecular spaces using a forceful jet of sterile water The ilia were then cut into oval shaped pieces 4 mm long and 2 mm wide, using a stainless steel punch and the remaining blood and marrow cells were flushed out until the pieces looked quite white Half of the pieces were then decalcified in a cold room (0° to 4° C) with continual agitation in 5 mm of 0 6 N hydrochloric acid (HCl) for 5 h The decalcified and the non decalcified bone were washed twice in one of three solutions 0 1 M (isotonic) sodium dihydrogen phosphate buffer at pH 7 4 70 per cent ethyl alcohol or 0 9 per cent sodium chloride Wash solutions were decanted and the bone stored each piece in a numbered sealed container by freezing to 20° C.

The preparation and implantation of the treated combined myelo osseous grafts

The recipients were 42 adult female rabbits Under anaesthesia small pouches were opened between the oblique muscles of the anterior ab dominal wall and a single graft was inserted into each pouch In order to standardize the host response to each type of implant used 13 im plants were inserted into each animal The types of implant used included iliac bone marrow alone and in the form of combined myelo osseous grafts, the marrow being aspirated from a femur of the recipient immediately before im plantation Table 1 shows the types of implant used As a control a single autograft of red marrow was inserted into a separate pouch

Three animals were killed at daily intervals up to 14 days after implantation

Retrieval of grafts and preparation for examination

Animals were anaesthetized and killed by in tracardiac vascular perfusion with glutaral dehyde through a carotid arteriotomy The an terior abdominal wall was removed, pinned on a cork board and fixed by immersion in a 2 5 per cent glutaraldehyde solution After fixation the abdominal wall was subjected to high de finition radiography Each graft site was then cut out in blocks of about 1 cm square, decal cified and prepared for histological examination staining 6 µm sections with haematoxylin and eosin No attempt was made to quantitate the amount of bone which formed as had been done previously (Nade & Burwell 1977)

RESULTS

Radiological studies

All 252 calcified implants were de tected One hundred and twenty-six de calcified grafts implanted alone did not produce radiological evidence of (re-) calcification

Decalcified allografts implanted com bined with *autologous marrow* showed evidence of calcification from the *eighth* day onwards This was small in quantity and in the form of scattered specks (Figure 1)

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OSTEOGENESIS AFTER BONE AND BONE MARROW TRANSPLANTATION

II. The Initial Cellular Events Following Transplantation of Decalcified Allografts of Cancellous Bone

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An experimental study was done in rabbits to investigate the fate of allogeneic iliac cancellous bone, both non-decalcified and decalcified with hydrochloric acid, transplanted to a muscular site for up to 14 days Some of the treated allografts were impregnated with autologous bone marrow cells, obtained from the femoral medulla by aspiration, and each was compared with allografts alone Combined myelo-osseous grafts produced bone after 7 to 8 days implantation, as did marrow autografts alone In addition non-decalcified implants stimulated the production of multinucleated giant cells Three different types of wash solution were used but these did not influence the cell population seen, nor the new bone formation It is concluded that the critical events in bone formation after transplantation occur less than 8 days after the transplantation and that marrow cells have osteogenic capacity This has relevance to the clinical aspects of bone grafting

Key words bone, bone transplantation, bone marrow cells, bone cells

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It has previously been shown by Nade & Burwell (1977) that decalcified iliac cancellous bone, impregnated with autologous bone marrow and grafted to a muscular site in rabbits, formed new bone by 14 days after implantation Also bone marrow autografts *alone* did this However, decalcified cancellous bone allografts, without bone marrow, produced, on some occasions, very small amounts of new bone but not until 4 weeks after implantation These findings were at variance with those of Urist's group (Urist et al 1967) who used cortical bone from the femoral diaphysis in various species and washed the bone in several different ways after decalcification with hydrochloric acid

In this paper are reported the morphological findings after implanting hydrochloric acid-decalcified allogeneic iliac cancellous bone, washed in three different ways, and impregnated with autologous bone marrow into the anterior abdominal wall of rabbits for periods of up to 14 days The critical events leading to osteogenesis take place during this time period



Figure 3 Photomicrograph of HCl decalcified phosphate washed allogeneic iliac cancellous bone implant combined with autologous marrow 12 days after insertion The newly formed bone (nb) containing osteocytes and lined by osteoblasts is easily distinguished from the non viable implant (ob) (Haematoxylin and eosin × 54)

being recognisable as such until bone had appeared New bone stained slightly more purple and had osteocytes in lacunae and surrounding matrix (Figure 3) A so called basophilic cement line formed a line of demarcation in some non decalcified implants Without the presence of a marrow autograft, *no* newly formed bone, nor osteoblasts were seen In the 42 marrow autogafts inserted alone these features were first seen on the seventh or eighth day after after implantation and when combined with any allogeneic bone implant bone did not appear before the eighth day The pattern was not altered by the method of washing the bone

d) *Multinucleated giant cells* These were not seen in marrow autografts nor around bone which had been decalcified before implantation In the 252 non decalcified implants they first appeared about 6 or 7 days after grafting while in the combined grafts (non decalcified) they were first noticed after 8 days with ethanol washed implants, 12 days with saline washed and were seen at various times in phosphate washed implants The significance of these differences is not clear however these cells were always seen about extremities of the implant, and usually in Howship's lacunae

DISCUSSION

The stimulation of osteogenesis and the identification of cells which contribute to the synthesis of bone matrix have been studied for over three centuries The considerable variation in findings reported has been due to the animal species used the interpretation of histology, the technical differences in laboratories and the acceptance of conclusions from statistically insignificant figures

In the interpretation of previously described work, one must be careful if one accepts the criterion of nuclear staining of osteocytes as indicating cell viability, for the findings of this study as well as of Yoshiki (1962) and Burwell (personal communication 1970) show that such a stain in non decalcified stored bone may be retained for up to 7 days, when the cells are by all accepted criteria non viable

Previous studies (Nade 1970, Nade & Burwell 1977) have failed to confirm the findings of Urist s group (Urist et al 1968) that HCl decalcified allografts of bone implanted into an intermuscular site evoke the production of newly formed bone presumably by the process of induction One variable was the method by which the bone was washed after decalcification This study shows that the cellular response, in the rabbit, is not influenced by the use of sodium chloride solution 70 per cent ethanol or in isotonic phosphate buffer Admittedly, Urist s group have used diaphyseal cortical bone while this study has used iliac cancellous bone however, Cummine & Nade (1977) showed that the cellular response around these two types of bone is not different (in the guinea pig)

The findings of earlier reports have been confirmed and have led to the conclusion that fresh bone marrow auto



Figure 1 Radiograph of implant site in abdominal wall 12 days after insertion of HCl-decalcified (radiolucent) cancellous iliac allograft combined with autologous marrow Scattered specks of calcification are seen, which on histological examination (Figure 3) were due to new bone formation (magnification × 6)

Twenty-six out of 42 autografts of marrow alone showed similar specks of calcification, increasing in quantity from the *fourth* day onwards

Histological studies

All implant sites showed evidence of surgical trauma with haemorrhage and surrounding fibrosis Haemorrhage was readily visible up to about the seventh day in all implants, and the fibrous capsule and fibroblastic reaction was maximal between 4 and 12 days, in all except the undecalcified grafts inserted alone in which this occurred between 8 and 13 days No differences were noted in the responses to the three different types of wash procedure

The morphological features were similar, except for the presence of ovoid cells, to those described in guinea pigs by Cummine & Nade (1977)

The staining of osteocytes within lacunae of the implanted bone, the detection of implanted bone, the presence of osteoblasts and newly formed bone and the presence of giant cells require separate description

a) *Staining of osteocytes* There was a difference in the persistence of basophilic nuclear staining of osteocytes in treated allogeneic implanted bone between the decalcified and non-decalcified implants Such staining could be seen on the day of implantation and the first day afterwards in HCl-decalcified grafts, but was retained until the seventh or eighth day in those not decalcified, but washed before implantation, either combined with marrow or alone

b) *Detection of implanted bone marrow* Where implants did not contain bone marrow, no features of marrow cells, or fat spaces were seen In combined myelo-osseous grafts, and in marrow autografts alone, the marrow portion of the implant was detected by the cellular distribution pattern and interspersed fat spaces (Figure 2) In marrow autografts the implant site was visible up to the fourteenth day—but decreased in intensity from the eighth day In combined grafts the marrow component was only easily detected until the seventh or eighth day, except in saline washed non-decalcified grafts where it persisted until the twelfth day

c) *The presence of osteoblasts and newly formed bone* These two features occurred simultaneously, osteoblasts not



Figure 2 Photomicrograph of undecalcified saline washed allogeneic iliac cancellous bone implant combined with autologous marrow 6 days after insertion The marrow component is identified by fat spaces (f) and some cellular aggregates adjacent to the implanted bone (ob) within the fibrous capsule (c) (Haematoxylin and eosin × 54)



Figure 3 Photomicrograph of HCl decalcified phosphate washed allogeneic iliac cancellous bone implant combined with autologous marrow 12 days after insertion The newly formed bone (nb) containing osteocytes and lined by osteoblasts is easily distinguished from the non viable implant (ob) (Haematoxylin and eosin × 55)

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The findings of earlier reports have been confirmed, and have led to the conclusion that fresh bone marrow auto

grafts are osteogenic (Bruns 1881, Danis 1956, Amsel & Dell 1971) and that marrow cells produce bone in the presence of decalcified allografts of cancellous bone (Burwell 1966, Pike & Boyne 1974) Whether such bone growth is stimulated by the allograft (Sabet et al 1964, Boyne 1970, Buring 1975) or whether it acts purely as a scaffold to retain the marrow autograft *in situ* (Burwell 1966) has not been determined There is a critical number of cells per unit volume (packing density) below which osteogenesis does not take place (Friedenstein et al 1966, Amsel & Dell 1971) However, the newly formed bone, and adjacent osteoblasts were present on the eighth day after implantation in this study, so that the critical events in the stimulation of osteogenesis occur well before that time has elapsed

Multinucleated giant cells were yet again (Nade 1970, Nade & Burwell 1977, Cummine & Nade 1977) seen around non-decalcified grafts, suggesting that the cellular morphology around skeletally derived implants is influenced by their physical and/or chemical nature (Young 1966) The significance of such giant cells is unknown, presumably they have a role in demineralization of hard pieces of bone, and by doing so, deplete the cell population surrounding an implant of potentially osteogenic cells

Although it has been suggested that the influence of skeletally derived tissues is at least partially masked or inhibited when bone is mineralized (Morris 1973, Nade & Burwell 1977) the time at which bone formed was not altered by the failure to decalcify although no attempt was made to assess the quantity of bone that formed

It has previously been shown (Bloom et al 1941, Tavassoli & Crosby 1968, Nade 1970, 1973) that cells within the bone marrow population are osteogenic Whether transplanted cells contribute directly by division and differentiation or whether they degenerate and their breakdown products stimulate bone formation in the surrounding connective tissue has not been clarified and advocates of the former (Dorr et al 1962, Friedenstein et al 1968, Danis 1973) and latter theories (Crosby 1970, Buring 1975) exist Certainly by light microscopy, one is unable to identify in the first 7 days after implantation those cells which are about to synthesize bone matrix Cummine & Nade (1977) have described ovoid cells in guinea pigs which appear adjacent to bone implants about the time that osteogenesis commences, but similar cells have not been detected in the rabbit Perhaps these are the primitive mesenchymal cells, or reticular cells described by Amsel & Dell (1971) Electron microscopy would be a useful tool in determining which cells in the first 7 days after bone marrow transplantation appear to be assuming osteoblast characteristics and bone matrix synthetic activity

Similar findings have now been described in rabbits of a different strain to those in this study (Nade & Burwell 1977), in the rat (Burwell 1966), the monkey (Boyne 1974), the dog (Newman & Boyne 1971), the guinea pig (Cummine & Nade 1977) and man (Marble et al 1970, Boyne 1974) under various experimental conditions

The formation of bone by marrow as a fundamental response to injury or insult of that tissue has been proposed (Cummine & Nade 1975) and the ability to control this response by the surgeon should make it possible to stimulate osteogenesis when and where it is required without the need for taking massive bone autografts (Nade 1970, Boyne 1973)

Decalcified allogeneic bone, preferably cancellous for its cell-retaining mesh of trabeculae, could be stored easily in sterile containers by freezing or lyophilisation and used as a relatively non-anti-

genic vehicle for implantation of osteogenic bone marrow—and possibly act as a stimulus to its osteogenic capacity. Despite previous attempts to provide bone-banks this hypothesis changes emphasis from the cellular to an environmental role for the skeletally derived graft.

Studies of the reconstruction of mandibular defects using such combined myelo-osseous grafts isolated from surrounding cells by a porous membrane (Boyne 1969; Richler & Boyne 1969) have suggested the direct involvement of such marrow cells. Mitchell & Marble (1974) do not believe that the calcified matrix of cancellous bone produces any significant osteogenic effect but acts as a restraining lattice for the marrow cells.

With the realization that living autografted bone marrow cells are osteogenic clinical trials should be undertaken to assess the potential of this type of boneless bone grafting.

SUMMARY

1. This paper reports a radiological and histological study of the fate of hydrochloric acid decalcified allogeneic iliac bone impregnated with autologous bone marrow and grafted to a muscular site in rabbits for up to 14 days.

2. After decalcification the bone pieces were washed in either 0.9 per cent sodium chloride solution, 70 per cent ethanol or 0.1 M isotonic phosphate buffer at pH 7.4. The treated pieces of bone were sealed in individual containers and stored by freezing. Non-decalcified bone similarly washed was used as a control in the same animal.

3. Bone marrow was obtained by aspiration from the femoral medullary cavity through a drill hole just before implantation and combined with the treated and stored allogeneic bone.

4. Autografts of bone marrow alone produced bone after 7 to 8 days implantation, as did combined myelo-osseous grafts.

5. In the absence of bone marrow no newly formed bone was seen.

6. Non-decalcified implants stimulated the production of multinucleated giant cells about them.

7. The type of wash used did not influence the cell pattern seen around the grafts nor the new bone formation.

8. The retention of nuclear staining by osteocytes cannot be accepted as evidence of cell viability.

9. The results of these and similar experiments using combined grafts of bone and marrow show that bone marrow autografts are osteogenic and this capacity may be controlled by the surgeon by varying the microenvironment in which the marrow cells are placed.

10. The critical events in bone formation after marrow injury by transplantation occur less than 8 days after such transplantation.

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RADIOTHERAPY AND SURGERY IN 50 CASES OF OSTEOSARCOMA TREATED WITHOUT ADJUVANT CHEMOTHERAPY

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A consecutive series of osteosarcoma patients from one hospital is described. In 1962 radiotherapy with delayed surgery according to Cade was replacing surgery alone as the adopted treatment programme. Statistically the results were the same before and after this time with 5 out of 29 and 6 out of 21 patients, respectively, surviving 5 years. With radiation alone none out of eight survived. Surgery alone produced 3 out of 14 and radiation with delayed surgery 6 survivors out of 15. As surgery with or without radiotherapy is equally in effective in controlling osteosarcoma a prospective randomized trial of the relative merits of chemotherapy and interferon as adjuvant therapy seems highly desirable.

Key words: osteosarcoma, radiotherapy, amputation

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Over the last 5 years the traditional methods of treatment for osteosarcoma including surgery with or without radiotherapy have gradually been replaced by new programmes combining surgery with chemotherapy. Before the introduction of modern programmes of this type the results of earlier regimes have been reviewed.

Evaluation of the results of therapy for osteosarcoma is often made difficult by the fact that consecutive series from single hospitals are generally small. Larger series are always collected from several different clinics and are reliable only when tumour registers are used (Larsson & Lorentzon 1974) but in such series there is always greater variation in therapy. The material may give valuable information when added to similar series from other clinics and, in the future, assessment of the results in series of this type will also be influenced by the effects of chemotherapy.

In 1962, it was decided at the University Clinic in Lund, to change the principle of therapy for osteosarcoma from surgery alone to radiotherapy with delayed surgery according to Cade (1955). This paper presents the results obtained with the former and the latter programmes both without adjuvant chemotherapy, and discusses the latest trends in the new programmes with chemotherapy.

Table 1 Basic data of all cases of osteosarcoma tabulated in the order of survival time

Case no	Sex	Age	Location	Therapy	Duration of symptoms (months)	Biopsy year	Time in months from biopsy to metastases	Time in months from biopsy to death
32	M	12	PH	R	1	1968	at diagnosis	2.5
23	F	29	PF	S	3	1951	not shown	3
1	F	52	DT	S	7	1962	not shown	3
26	M	70	PFe	R	8	1969	not shown	3
10	M	5	PH	R	1	1954	2.5	3.5
3	F	12	DF	R	0.5	1958	1	5
16	M	21	DF	RS	6	1959	3.5	5
29	F	33	DF	S	2	1957	not shown	5
33	M	14	DF	SR	1	1948	3	5
40	M	47	DF	R+6+S	8	1967	at diagnosis	6
44	F	9	DF	SR	3	1962	4.5	6
9	M	22	PFi	R+6+S	3	1969	2.5	6.5
2	F	13	PT	RS	2	1956	not shown	7
6	F	8	DF	R	3	1967	2	7
24	M	9	PF	R	2	1953	4.5	8.5
20	F	41	Mand	SR	7	1946	4.5	9
27	F	64	PT	S	2	1957	8	9
18	F	70	Calc	S	6	1952	2	10
39	M	17	DF	RS	1	1946	7	11
8	F	19	PHu	RS	7	1959	4	11
41	F	7	DF	R+6+S	1	1972	4	11
36	F	3	PF	R+6+S	1	1970	8	11.5
45	M	19	DF	S	4	1968	5	11.5
15	M	18	DF	R+6+S	3	1953	5.5	12
25	F	69	PH	RS	8	1968	not shown	12
28	M	30	DF	RS	7	1964	2	14
49	F	10	DF	R+6+S	7	1962	6	15
34	F	38	DF	S	1	1958	13.5	17
42	M	7	PH	R	1	1952	14	17.5
17	M	21	DF	R+6+S	12	1965	12	19
43	M	11	PH	R+6+S	4	1968	4	19.5
35	M	26	DF	S	10	1948	13.5	22.5
7	F	33	DR	S	5	1957	6	32
31	M	44	PH	R+6+S	6	1969	7	37.5
4	M	37	DF	S	2	1960	26	41
21	F	32	PT	SR	7	1945	not shown	59
48	M	19	PT	R	5	1966	35	72
13	F	35	PT	S	16	1947	98	102
50	F	22	PH	SR	7	1952	132	156
12	M	10	PT	R+6+S	9	1972	None	Alive (5 years)
11	F	33	Sca	S	3	1970	None	Alive (7 years)
46	M	22	DF	RS	2	1969	None	Alive (8 years)
30	F	41	PT	R+6+S	4	1967	4	Alive (10 years)
5	M	11	DF	R+6+S	11	1965	None	Alive (12 years)
47	M	20	PT	R+6+S	4	1963	16	Alive (14 years)
37	F	11	DF	R+6+S	6	1959	None	Alive (18 years)
22	M	18	PT	S	2	1958	47	Alive (19 years)
14	M	16	DF	R+6+S	3	1953	None	Alive (24 years)
19	M	13	DF	S	3	1953	None	Alive (24 years)
38	M	8	DF	RS	7	1949	None	Alive (28 years)

D = distal F = femur H humerus P = proximal R = radiotherapy only RS = radiotherapy followed immediately by surgery R+6+S = radiotherapy followed by surgery delayed 3 6 months S = surgery only T = tibia

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RADIOTHERAPY AND SURGERY IN 50 CASES OF OSTEOSARCOMA TREATED WITHOUT ADJUVANT CHEMOTHERAPY

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A consecutive series of osteosarcoma patients from one hospital is described In 1962 radiotherapy with delayed surgery according to Cade was replacing surgery alone as the adopted treatment programme Statistically the results were the *same before* and *after* this time with 5 out of 29 and 6 out of 21 patients, respectively, surviving 5 years With radiation alone none out of eight survived Surgery alone produced 3 out of 14 and radiation with delayed surgery 6 survivors out of 15 As surgery with or without radiotherapy is equally in effective in controlling osteosarcoma a prospective randomized trial of the relative merits of chemotherapy and interferon as adjuvant therapy seems highly desirable

Key words osteosarcoma, radiotherapy, amputation

Accepted 20 vi 77

Over the last 5 years the traditional methods of treatment for osteosarcoma including surgery with or without radiotherapy have gradually been replaced by new programmes combining surgery with chemotherapy Before the introduction of modern programmes of this type the results of earlier regimes have been reviewed

Evaluation of the results of therapy for osteosarcoma is often made difficult by the fact that consecutive series from single hospitals are generally small Larger series are always collected from several different clinics and are reliable only when tumour registers are used (Larsson & Lorentzon 1974) but in such series there is always greater variation in therapy The material may give valuable information when added to similar series from other clinics and, in the future, assessment of the results in series of this type will also be influenced by the effects of chemotherapy

In 1962, it was decided at the University Clinic in Lund, to change the principle of *therapy for osteosarcoma* from surgery alone to radiotherapy with delayed surgery according to Cade (1955) This paper presents the results obtained with the former and the latter programmes both without adjuvant chemotherapy, and discusses the latest trends in the new programmes *with chemo* therapy

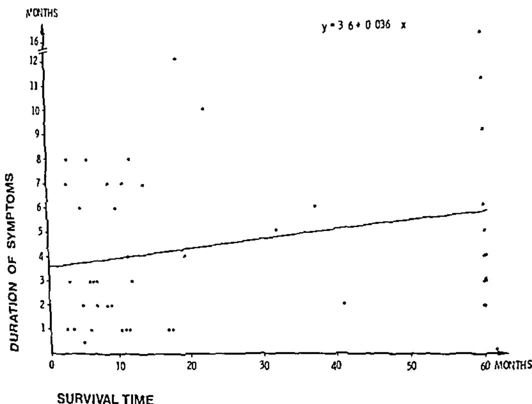


Figure 2 Survival time versus duration of symptoms

duration of symptoms in months before biopsy and the time interval in months before evidence of metastases and before death ensued There is some correlation between age and duration of symptoms (Figure 1) Survival time versus duration of symptoms is shown in Figure 2 No case with symptoms for 2 months or less were among the survivors but in general the correlation in this material is weak Before 1962 5 cases out of 29 survived 5 years from 1962 6 out of 21 survived 5 years Before 1962 12 out of 29 patients were treated with surgery alone From 1962 2 out of 21 were treated with surgery alone The general 5-year survival was 17 per cent before 1962 and 29 per cent since 1962 but the difference is not statistically significant according to Fischer s test ($P = 0.054$ for the combined material) In the total material of 50, 8 patients treated with radiation alone produced no survivors Surgery alone produced 3 out of 14 and delayed surgery after radiation six 5-year survivors out of 15 (Tables 1, 2, 3)

Table 2 Survey of planned therapy and disease free survival

Therapy	No	5 year survival
Amputation only	14	3
Amputation + secondary radiotherapy	5	0
Radiotherapy for delayed amputation	15	6
Radiotherapy + immediate amputation	8	2
Radiotherapy only due to metastases	8	0
Total	50	11

MATERIAL

During the period 1945 through 1972, 74 patients with a diagnosis of osteosarcoma were registered at the University Hospital in Lund, Department of Orthopaedic Surgery or Radiotherapy After reviewing our records and histological preparations, 50 were accepted as osteosarcoma according to the WHO classification Twenty-four cases were rejected by the histopathologist as chondrosarcoma (8), fibrosarcoma (4), undifferentiated sarcoma (3), giant cell tumour (2), chondromyxosarcoma (2), osteoblastoma (1), fracture (1), Ewing sarcoma (1) In two patients the histological preparations were unacceptable for a diagnosis and the cases were rejected In three, cytological needle biopsy preparations alone were accepted at the review

The distribution of age was typical and there were 27 males and 23 females (ratio 1 3 1) If only patients below 25 are considered the ratio is 2 4 1 Table 1 presents the basic data of all 50 patients with osteosarcoma

METHODS

Up until 1962 the principle of therapy was amputation when surgically possible For sarcoma in the distal femur transmedullary amputation was used For sarcomas in the diaphyseal region or more proximally disarticulation was performed Radiotherapy was used only for cases where surgery was impossible or where it had been tried but proven insufficient at pathology

From 1962, biopsy was followed by radiotherapy according to Cade (1955) but using high voltage equipment Doses of 6 500–7 500 rad were given and amputation was carried out 4–6 months later In cases where fracture or continuation of tumour growth occurred in spite of radiotherapy, amputation was performed earlier

RESULTS

Table 1 describes the cases in order of survival time Sex, age and location of tumour are shown as well as therapy,

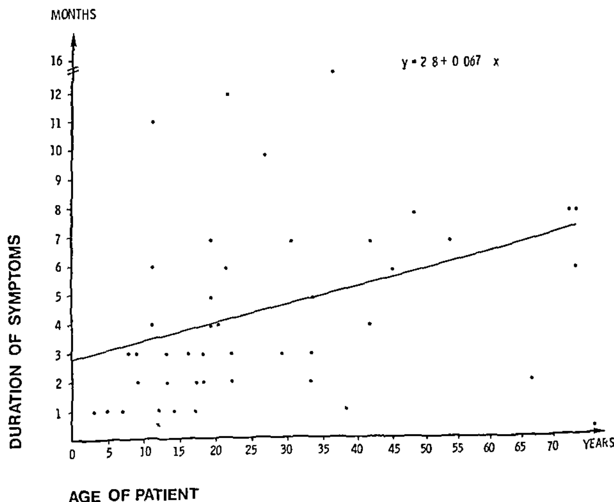


Figure 1 Age versus duration of symptoms

limb and replacing the structure with a custom made prosthesis Jaffe & Watts (1976) conclude that a transmedullary amputation through the involved bone rather than removal of the entire bone should now be safer than before (Foss et al 1966)

The rarity of osteosarcoma and the delicacy of cytostatic adjuvant programmes now more than ever make centralized treatment with coordinated programmes a necessity As soon as the results of adjuvant interferon are finally analyzed it should be possible to begin a Scandinavian programme comparing interferon with chemotherapy Surgery alone or preoperative radiotherapy with delayed surgery both have proven insufficient but statistically comparable From now on adjuvant programmes are running prospectively to make contemporary controls possible

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Table 3 High voltage radiation before delayed surgery, primary plan and final outcome

Therapy	No	5-year survival
Amputation after 6 months	8	6
Amputation before time due to complications	2	0
Amputation not carried out due to metastases	5	0
Total	15	6

DISCUSSION

This consecutive and unselected series shows a 5-year cure rate and a 5-year survival rate of 18 and 26 per cent, respectively Four patients had pulmonary metastases resected, two were disease-free 5 years later When the material is divided according to therapy, the group with radiation and delayed surgery has a survival rate and a cure rate which is greater than those with surgery alone but the differences are not statistically significant

In 1962 the Cade principle was adopted When the results after this time are compared with those from the earlier period the survival rate is a bit better but again the difference is statistically not significant Many materials support this conclusion (Cederlof et al 1960, Dahlin & Coventry 1967, Lindblom et al 1961, Poppe et al 1968) Sweetman et al (1971) recorded 14 out of 61 surviving amputation alone and 22 out of 80 surviving radiotherapy with delayed amputation In France, Trifaud & Merry (1972) made a broadbased review of the literature studying this question and recorded a 21 per cent 5-year cure rate with amputation alone in 903 cases and a 23 8 per cent rate with delayed surgery after radiotherapy in a series of 501 cases studied The material presented in this paper agrees with this It should therefore be remembered that in cases where immediate surgery for one reason or another is not feasible, radiotherapy with the surgery postponed for 4 to 6 months does not adversely influence the results This type of programme should not be used in cases where the tumour has already made the function of the limb inferior to that of a prosthesis When the function is good and the pain is controlled by the radiotherapy the possibility of delaying surgery must be kept in mind for special cases Campannacci & Cervellati (1975) from Italy reviewing 345 cases came to the same conclusion

Since the first trials with chemotherapy (Phenylalanin mustard in Huston, Texas, in 1963) Adriamycin alone or in combination with other drugs has produced encouraging early results Pritchard (1976, personal communication) at the Mayo Clinic believes that during the last 5 years the general prognosis of osteosarcoma may be better than before thereby making historical controls for evaluating the effects of chemotherapy misleading The 2-year survival rates seem to rise from around 30 per cent without chemotherapy to between 50 and 75 per cent with chemotherapy (Cortes et al 1972, Jaffe & Watts 1976, Rosen et al 1974, Sutoff et al 1974)

Other types of adjuvant therapy for osteosarcoma which have been tried with hopeful early results are adoptive immunotherapy (Neff & Enneking 1975) and interferon (Nilsonne et al 1975) Interferon as in effective adjuvant to surgery may support the theory of a viral aetiology

Although it is not proven that these adjuvant programmes are producing better results in the long run, the early figures have given a new interest in reducing the magnitude of mutilating surgery for these patients Marcove (1975 1977, personal communication) as well as Sneath (1976, personal communication) are concentrating on extirpation of the bone involved with preservation of the

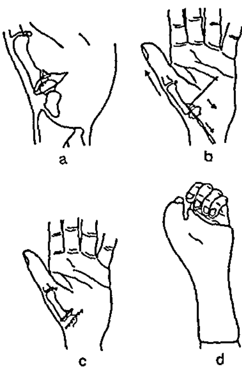


Figure 2 Internal fixation ad modum *Gedda & Moberg (1953)*

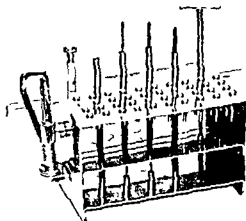


Figure 3 Instrumentarium

treatment and presenting a great many cases Subsequent progress in the field of internal fixation has made it possible to develop the method of treatment described by Moberg (1952) (Figure 2)

Gedda pointed out that the prognosis for Bennett's fracture depends to a great extent on the choice of therapy If exact or almost exact reduction can be achieved, the results are very good

The internal fixation of Bennett s fracture can be performed by means of a screw (Ruedi et al 1971) or a Kirschner wire (Moberg 1952), depending on the size of the tuberculum fragment The purpose of screw fixation is to achieve a rigid internal fixation Difficulties arise, however, in maintaining the reduction of the fracture during the insertion of the implant and in securing an ideal position for the implant With the instruments described below, the operation is simplified and there is less need for assistance

MATERIAL AND METHODS

The set of instruments (Figure 3)

The instrumentarium consists of the following

1 A guide and fixation instrument, with a guide hole that is some tenths of a mm wider than the head of the osteosynthesis screw (Figure 4)
2 One 2 7 mm and one 2 0 mm wide drill fitted to batons that are slightly smaller than the hole in the guide instrument (Figure 5 a + b)
3 A threaded tap fitted to a baton of the same thickness as those for the drills (Figure 5 c)
4 A screw driver of the Phillips type for the osteosynthesis screw (Figure 5 d)
5 A guide for the Kirschner wire, resembling a thick walled tube Its external diameter is the same as that of the hole in the guide and fixation instrument and its internal diameter is some tenths of a mm larger than the Kirschner wire (Figure 5 e)

In the case of big fragments, the internal

... to cause rotation and damage to the fragment than a cancellous screw In cases of small fragments the internal fixation is performed by means of a 2 mm Kirschner wire Whether a screw or a wire is used it must run perpendicular to the fracture surface

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COMPRESSION FIXATION OF BENNETT'S FRACTURE

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A procedure that ensures exact reduction and internal fixation of Bennett's fracture is presented. In cases with a large tubercular fragment, the internal fixation is performed with a lag screw technique. *If the fragment is small,* a Kirschner wire is used as an implant. A special set of instruments that keeps the reduced fragment in position and guides the implant during the internal fixation process is also described.

Key words: Bennett's fracture, small fragment fracture, metacarpal fracture, thumb injury, internal fixation, internal fixation of small fragments, lag-screw fixation

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Ever since 1882, when the Irish surgeon E. H. Bennett described a fracture of the palmar tuberculum of the first metacarpal, causing subluxation in the first metacarpal joint (Figure 1), this injury has attracted great interest, in spite of the fact that it is relatively uncommon. In a large number of fracture injuries, Bennett's fracture accounts for only 0.4 per cent (Gedda 1954). There are two main reasons for this interest.

1. A neglected or incorrectly treated Bennett's fracture will cause a posttraumatic osteoarthritis in the first metacarpal joint. The loss of stability in the joint considerably reduces the force of the thumb and with it the gripping ability of the hand. The injury tends to affect the hand of preference in people in their most active age and can considerably impair their capacity for work.

2. The fracture has earned the reputation of being easy to reduce but difficult to keep in position.

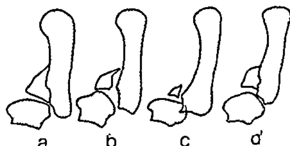


Figure 1. Bennett's fracture. Classical forms (a and b) with small fragment (c) and impact fracture (d).

A great variety of treatments, open as well as closed, have been described and recommended (Moberg 1952, Lamaste & Cedard 1959, Lemerle 1960, Pollen 1968). The underlying principles are difficult to evaluate because none of the published series has exceeded 15 cases, with the exception of the monograph by Gedda (1954). This work on Bennett's fracture is the most extensive and important, discussing comprehensively the history, mechanics, pathophysiology, diagnosis and

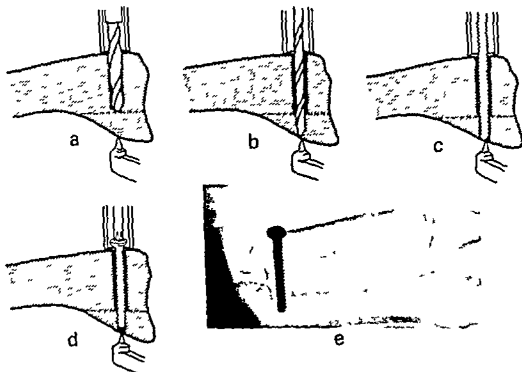


Figure 6 Performance of internal fixation a) drilling through main fragment b) drilling through palmar fragment c) tapping d) inserting screw e) screw applied

dicating the length of the screw required (Figure 4) The screw temporarily fixed to the screw-driver with albumin for example is inserted through the main instrument and screwed into the bone tunnel (Figure 6 d) This results in rigid fixation of the fracture and compression between its surfaces The muscles are sutured and the incision closed

If the palmar fragment is too small to be screwed internal fixation with compression must be abandoned The fragment is instead fastened with a Kirschner wire as described by Moberg (1952) This can be successfully accomplished with the instruments described above When the fracture has been temporarily reduced the tubular guide (Figure 5 a) for the Kirschner wire is inserted into the tunnel in the main instrument The wire is fastened into a hand surgery drill and placed in the tubular guide so that it can be drilled through the cortex of the main fragment and out through the cortex of the palmar fragment (Figure 7 a) The wire is passed out of the palmar fragment close to the tip of the main instrument The main instrument is then removed and the wire cut off

The joint is immobilized in a plaster bandage extending from the interphalangeal joint of the thumb engaging the entire middle hand and up onto the forearm The operated hand is kept in an elevated position

With internal fixation by means of a screw, the plaster is removed after 3 weeks and the screw after 2 months With Kirschner wire fixation the plaster must be retained for at least 4 weeks and the wire extracted after a further 2 months As soon as the plaster has been removed the patient should start to exercise the hand and fingers

The operation need not be performed in the acute stage but preferably within 1 week after the accident This allows time for preoperative preparation of the skin and for the traumatic oedema to decrease The internal fixation material should be removed 4 months after operation—a procedure for the outpatient department

Patients

During a 5 year period the instruments described have been used in 11 patients all men between 23 and 54 years of age All the injuries had involved the hand of preference and caused

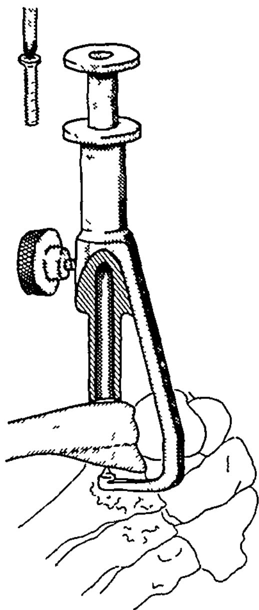


Figure 4 Guide and fixation instrument

Procedure

The fracture is exposed as described by Moberg (1951) and Gedda & Moberg (1953) (Figure 2 a) The operation is performed under general or regional anaesthesia An arched incision (Figure 2) approximately 3 cm long is made over the base of the thenar muscles at right angles to the line of the thumb on the volar side of the tendon to adductor pollicis longus The thenar muscles must be partially dissected from the aponeurosis The joint is opened and the fracture haematoma and small crush fragments are removed Traction is applied along the axis of the thumb at about 60° to the axis of the forearm Thus the subluxation and the fracture are reduced under visual control In order to maintain traction a silk netting for finger traction (Silk finger grip Zimmer G B) may be used This netting can be fastened to the operation table so that the reduction is maintained while the osteosynthesis is carried out The sharp tip of the main instrument is placed on the palmar fragment and the cylinder is pressed down against the main fragment (Figure 4) In this way, the fracture is temporarily fixed while fully visible and a check can be made that continuity of the joint surface is restored A lock screw in the main instrument is used to keep the cylinder in place

The 2 7 mm drill is fitted to a hand surgery drill and inserted into the hole in the cylinder A hole is drilled through the cortex of the main fragment (Figure 6 a) After this a hole is drilled in the same way through the cancellous bone and the cortex of the palmar fragment with the 2 mm drill (Figure 6 b) The tip of this drill passes close to the tip of the main fragment The tap is used to produce a thread in the drilled tunnel (Figure 6 c) The two plates on the main instrument are now as far apart as the length of the drilled tunnel in

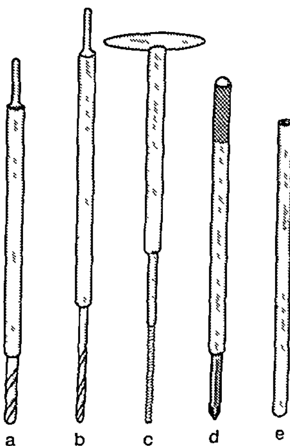


Figure 5 Auxiliary instruments for internal fixation a) 2 7 mm drill b) 2 0 mm drill c) tap d) screw driver Phillips type e) guide for Kirschner wire

by means of the lag screw technique or with the aid of a Kirschner wire, and the method described reduces the need for assistance

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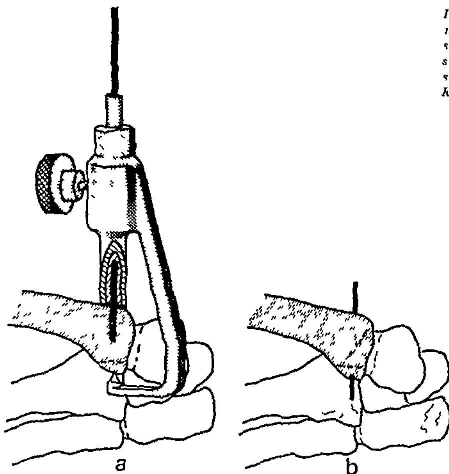


Figure 7 Kirschner wire guide in main guide and fixation instrument a) Kirschner wire inserted b) internal fixation of a small palmar fragment with a Kirschner wire

fractures of the palmar tuberculum of the first metacarpal bone with concomitant subluxation of the thumb

Nine of the cases were treated by means of *the lag screw technique and two with Kirschner* wires as internal fixation material All the patients presented good primary results *and* 2 years after the operation there was no residual *incapacity of the thumb in 10 patients In one* patient who was notoriously rowdy, the internal screw fixation and the good reduction achieved was eliminated in a new fight some days after the operation

None of the cases have been followed for more than 2 years postoperatively The implants were removed 4 months after surgery in all cases except the one where the internal fixation was ruined

DISCUSSION

All reports of Bennett's fracture point out the necessity of reducing both the subluxation in the *metacarpal joint* and the fracture It is generally considered and postulated that exact reduction and reconstruction of the joint surface in intra-articular fractures prevents postfracture osteoarthritis

It is impossible to determine during the operative procedure whether the reduction achieved is exact without opening the joint capsule and evacuating the haematoma (Gedda 1954) Furthermore, the small fragments of cancellous bone must be removed to enable exact reduction and performance of a rigid internal fixation

The treatment of Bennett's fracture with internal fixation, as described above, decreases the risk of postfracture osteoarthritis by increasing the chance of achieving and maintaining exact reduction The method permits reduction under visual control and the reduction is maintained *during the fixation procedure* The fixation is accomplished either

by means of the lag screw technique or with the aid of a Kirschner wire and the method described reduces the need for assistance

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THE CARPUS IN CONGENITAL ANOMALIES OF THE HAND

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Congenital anomalies of the carpus associated with congenital hand and upper limb anomalies were investigated from the point of view of the development of the hand Defects of the carpus were categorized as follows 1) Radial ray defect loss of the scaphoid trapezium and trapezoid 2) Central ray defect loss of the capitate and loss of a part of the trapezium and hamate 3) Ulnar ray defect loss of the triquetrum pisiformis and hamate Deficiencies of the carpus and more distal parts of the hand proved to be secondary to defects of the forearm bones in both the radial and ulnar ray On the other hand deficiency of the carpus was secondary to defects of the phalanx and metacarpal of the middle finger in the central ray Thus from the standpoint of the development of the carpus bipolar development of the bones of the hand originates proximally in both the radial and ulnar rays and distally in the central ray

Key words carpal bones, congenital anomaly, radial, central ulnar rays

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Congenital anomalies of the carpal bones are rare Isolated carpal anomalies such as fusion, absence, separation and accessory bone have however been documented (Hammond 1947, Rushforth 1949, Waugh & Sullivan 1950, Cockshott 1966, Roche 1967, Szaboky 1969, Garn et al 1971, Srivastava & Kochhar 1972) On the other hand, carpal bone anomalies are frequently observed in association with other congenital hand and limb anomalies, thus indicating the relationship of carpal bone development to the development of the whole limb (O Rahilly 1953, Poznanski & Holt 1971, Kelikian 1974) However, the development of the carpus, in relation to the development of the whole limb or the hand, has not been clearly documented In what way deficiency of the carpus is related to limb deficiency, or correlates with finger deficiency has not been elucidated

Limb anomalies have been classified in various ways Frantz & O Rahilly (1961) divided limb defects into two groups, viz, terminal and intercalary defects Entin et al (1966) and Swanson (1966) outlined the original classification based on embryological considerations in the committee report to the American Society for Surgery of the Hand Kay and associates (Kay et al 1973), a working group of the International Society for Prosthetics and Orthotics proposed an international terminology for the classification of congenital limb deficiencies,

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In the present paper an attempt will be made to classify anomalies of the carpus in relation to the precursor defect of each anomaly in order to establish the developmental relationship between the carpus the whole limb and the hand

PATIENTS

Among the Japanese patients with congenital anomalies of the hand who attended the Hand Clinic at Osaka University Hospital during the past 16 years 19 cases of radial ray defects 8 cases of ulnar ray defects and 30 cases of cleft hands were investigated (Table 1) Of these cases 19 were sufficiently developed to permit X ray evaluation

Table 1 Fifty seven cases with congenital anomalies of the hand

	Total cases	Mature cases
Radial ray defect	19	12
Cleft hand	30	5
Ulnar ray defect	8	2

FINDINGS

Radial ray defect

Riordan (1955) divided congenital absence of the radius into two main groups, i e total absence and partial absence and described the associated carpal bone anomalies Heikel (1959) also reported three types of radial ray defects combined with carpal bone anomalies According to the extent of the longitudinal defect of the radius we divided the radial ray defect into four groups

1) total radius defect (very severe)
2) partial radius defect (severe)
3) hypoplastic radius (mild)
4) normal radius (minimal)

Carpal bone anomalies in each group were investigated Ten cases were bilateral and nine unilateral There were eleven males and eight females Carpal anomalies occur in various ways depending on the grade of radial ray defect The most severe type shows total radius defect with or without absence of the thumb and index finger (Figure 1) In this type, the scaphoid, trapezium and trapezoid bones are generally absent, but the other carpal bones are always intact Occasionally, the central carpal bones are fused

The next group shows a partial radius defect associated with a total defect of the scaphoid and trapezium (Figure 2) In these cases floating thumb, hypoplastic thumb or other severe anomalies of the thumb with a defect of the first metacarpal are usually present

The third group presents a hypoplastic trapezium and/or defect of the first metacarpal (Figure 3) Eaves & Campiche (1922) reported a similar case

In the fourth group there is a normal radius with a hypoplastic thumb This anomaly is considered to be the most benign and presents only a hypoplasia of the scaphoid and trapezium (Figure 4) Hanley & Conlon (1957) described the benign form of the radial defect Thus, the carpal bone anomaly appearing in each grade of radial ray defect ranges from very severe to minimal It varies in extent and severity depending upon the radial ray defect (Figure 5) The development of the radial carpal bones, which include the trapezium, trapezoid and scaphoid is apparently closely related to the development of the radius The development of the thumb and first metacarpal appears to be related to the development of more the distal parts

Ulnar ray defect

Straub (1965) reported five cases of ulnar defect and Ogden et al (1976) eleven cases An analysis of the carpal

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THE CARPUS IN CONGENITAL ANOMALIES OF THE HAND

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Congenital anomalies of the carpus associated with congenital hand and upper limb anomalies were investigated from the point of view of the development of the hand Defects of the carpus were categorized as follows 1) Radial ray defect loss of the scaphoid trapezium and trapezoid 2) Central ray defect loss of the capitate and loss of a part of the trapezium and hamate 3) Ulnar ray defect loss of the triquetrum pisiformis and hamate Deficiencies of the carpus and more distal parts of the hand proved to be secondary to defects of the forearm bones in both the radial and ulnar ray On the other hand deficiency of the carpus was secondary to defects of the phalanx and metacarpal of the middle finger in the central ray Thus from the standpoint of the development of the carpus bipolar development of the bones of the hand originates proximally in both the radial and ulnar rays and distally in the central ray

Key words carpal bones, congenital anomaly, radial central ulnar rays

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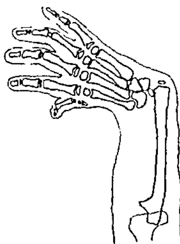



Figure 1. Roentgenogram of the right hand of an 8 year-old girl showing total radius defect floating thumb and a most severe anomaly of the carpal bones, i e , defect of the trapezium and scaphoid and fusion between the capitate and trapezoid

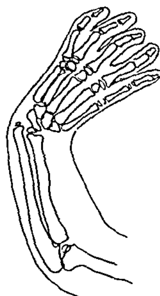



Figure 2 Nine-year-old girl Note the partial defect of the radius five fingered hand and severe anomaly of the carpal bones, i e , total defect of the scaphoid and trapezium and fusion between the lunate and triquetrum

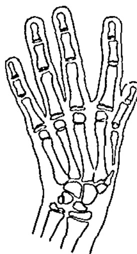
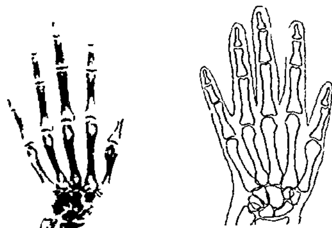



Figure 3 Ten-year old girl Note the hypoplastic radius partial defect of the first metacarpal, defect of both the scaphoid and trapezoid, and hypoplastic trapezium

Figure 4 Twenty three year old female complained of hypoplasia of the left thumb and thenar muscles Note the hypoplasia of the scaphoid and trapezium also



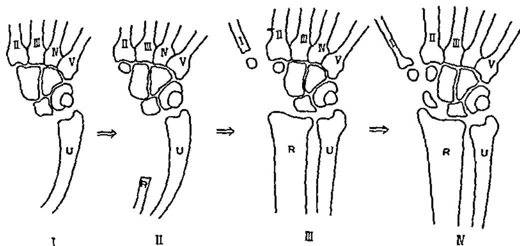


Figure 5 Illustration of the grades of severity of the radial ray defect Abnormality of the radial carpal bones is also classified into four grades according to the severity of the defect of the radius itself

bone anomaly however was not included in their reports In the present work we studied eight cases in which carpal bone anomalies were combined with ulnar ray defects The ulnar ray defect is classified according to the longitudinal defect of the ulna but is a less common anomaly than the radial ray defect This defect involves the ulna carpal bones and the two ulnar fingers and ranges from total ulnar defect to mere hypoplasia of the little finger alone The triquetrum pisiformis and hamate are absent, hypoplastic or fused depending on the grade of ulna defect In our series, eight cases were registered but only two cases were mature enough to be classified as partial defect of the fifth metacarpal associated with carpal anomalies In one of these two cases there was fusion of capitate hamate and hypoplasia of triquetrum and pisiformis (Figure 6) The severity of this case resembles that seen in the third group of patients with a radial ray



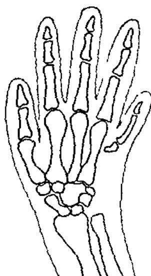


Figure 6 Seventeen year old girl with hypoplasia of the ulna partial defect of the fifth metacarpal and carpal bone anomalies



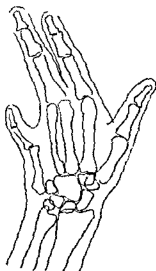


Figure 7 Eighteen year old girl with anomalies similar to the carpal bone anomalies of the case in Figure 6 Ossal syndactyly of middle and ring fingers is also evident



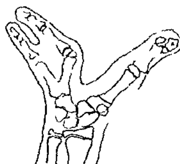


Figure 8 Eleven year old girl with defects of the second and third metacarpals and the capitate

defect In the second case, a hypoplastic fifth metacarpal with a normal ulna was associated with fusion of the capitate hamate and hypoplasia of triquetrum and pisiformis (Figure 7) Because osseous syndactyly of the middle and ring fingers

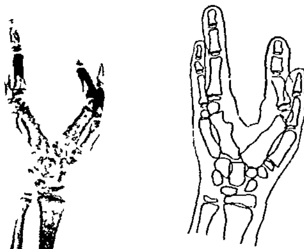


Figure 9 Roentgenogram of a 10 year old boy with total defect of the third metacarpal and a fairly normal capitate

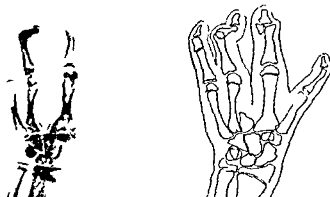


Figure 10 Fifteen year old boy with a partial defect of the third metacarpal and normal carpal bone

was also present this does not appear to be a typical case of ulnar ray defect Thus the development of the ulnar carpal bones in the ulnar defect is much the same as that in the radial ray defect

Central ray defect cleft hand

Thirty cases in which carpal bone anomalies were combined with a central ray defect were studied

Cleft hand includes various types of anomalies and classification has been made by many authors Barsky (1964) divided these into the typical and atypical types The atypical types included other anomalies such as symbrachydactyly, congenital amputation or microdactyly In the present study, 30 cases were considered typical cleft hand Eight hands were sufficiently mature for evaluation and were classified according to the extent and grade of the central ray defect Various degrees of carpal bone defect were also noted The defects were graded and divided into three groups The most severe group shows a total defect of the metacarpal and possibly neighbouring metacarpals (Figure 8) The carpal anomaly in this case includes total defect of the capitate and partial defect of the hamate and trapezium By contrast the other carpal bones are fairly intact

In the next group, only a third of the



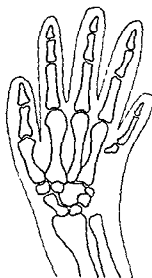


Figure 6 Seventeen-year-old girl with hypoplasia of the ulna, partial defect of the fifth metacarpal and carpal bone anomalies.



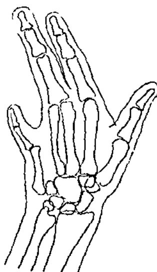


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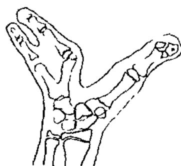


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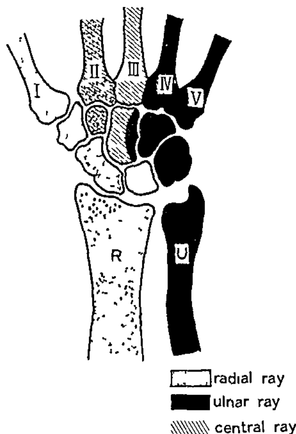


Figure 11 The three rays to which each element belongs

metacarpal and the middle finger are absent with the other finger rays intact (Figure 9) Partial defect or hypoplasia of the capitate is sometimes observed but in other cases it is normal In the *most benign group, a partial defect of the* third metacarpal and defect of the middle finger are observed The carpal bones are always normal in this type (Figure 10)

DISCUSSION AND CONCLUSION

In 1924 Kato postulated that the upper extremity consisted of a main stem and four accessory rays Since his report the terms "radial ray" and "ulnar ray" have been used and applied for purposes of morphological description of limb deficiency, such as radial hemimelia or ulnar hemimelia (O'Rahilly 1951) The present concept is *based on* limb development with the forearm and hand consisting of three rays, i e , radial, ulnar and central However, exactly where each carpal bone should be placed appropriately with reference to these rays has not been defined nor has the precursor defect of each carpal bone deficiency

Based on the clinicoradiological study of 57 hand anomalies the following conclusions were drawn

From the point of view of development the hand consists of three rays, viz, radial, central and ulnar Each carpal bone is also considered to belong to one of these rays as clearly indicated in Figure 11

The development of the radial ray division of the carpal bones was found to be related to that of the radius, based on the analysis of four types of radial ray defects in our series

The ulnar ray was confirmed to include the ulna, triquetrum, pisiformis hamate, a part of the capitate, the fourth and fifth metacarpals and the two ulnar fingers The development of this ulnar division of carpal bones was also found to be related to that of the ulna in the same manner as seen in the radial ray The central ray was confirmed to consist of the capitate, a part of the trapezoid, a part of the hamate, three central carpals and *the three central fingers* In comparison with the other two divisions, carpal bones of this central ray division show a quite different mode of development Here the development precedes from the distal part of the hand, as determined from various carpal bone anomalies in the cleft hand An anomaly of the lunate was not detected in any patient with a central ray defect

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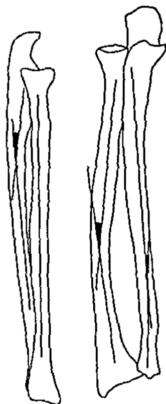


Figure 1 Diaphyseal angulation method of measurement In the a p projection the ulna has usually two curvatures Only the distal one was included In this case the angulation in the lateral projection of the radius is O

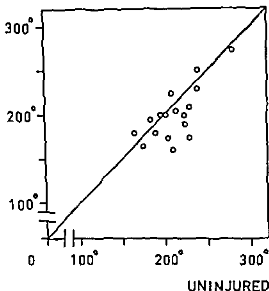


Figure 2 Pronation–supination deviation from the null hypothesis

Table 1 Pronation–supination in the fractured and the non fractured forearms

	Average	SD
Fracture	195°	± 37°
Non fracture	214°	± 27°
Difference	19°	

method is in normal individuals about 12° or 6 per cent (coefficient of variation) Since mal position visible at the former site of the fracture could not be expected and was not found the shape of the radius and the ulna with regard to curvature was recorded as shown in Figure 1 Measurements of angulation obtained in this manner were used for a comparison between the injured and the uninjured forearms

RESULTS

None of the patients had sought medical attention because of their forearms during the time interval between the healing of the fracture in childhood and the follow up examination Only one had any complaints whatsoever This patient felt some weakness of the forearm and hand and had (compare below) the greatest limitation of range of motion of all those tested In the entire group the range of pronation and supination motion was somewhat decreased in the previously fractured forearms and this decrease was significant The difference was about 20° (Table 1) The distribution of pronation and supination in relation to the null hypothesis is also demonstrated in Figure 2

The curvature of the ulna seen from the lateral aspect was significantly less in fractured arms but the difference was negligible Otherwise there was no difference in the various angles which could

THE RANGE OF MOTION FOLLOWING FRACTURE OF THE SHAFT OF THE FOREARM IN CHILDREN

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Eighteen children with fracture of the shafts of the forearm were re-examined in adulthood. All fractures had primarily been displaced but reduced to a good position without residual axial or *ad latem* displacement. At follow-up there was no sign of deformity in the radiograms of the two bones. However, the range of motion for supination and pronation was significantly decreased. This implies that factors other than residual deformity are responsible for this dysfunction.

Key words: fracture, forearm, diaphysis, deformity

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Högström et al. (1976) found that limitation of pronation and supination was a common finding after diaphyseal forearm fractures in childhood. The dysfunction was related to angulation caused by incomplete reduction of the fracture. This relationship, however, was weak with a large residual variance leaving most of the limitation unexplained. Therefore it was decided to investigate whether or not limitation of these movements could be found after fractures of the shafts of the forearm in childhood which had been properly reduced and which had healed in a good position.

MATERIAL AND METHODS

During the years 1954–1960 about 40 cases of diaphyseal fracture of the forearm in children below the age of 13 were recorded. Of these 28 fulfilled the criteria that there had been a substantial initial fracture displacement and that this displacement had been reduced completely. Of these patients 18 (11 men and 7 women) volunteered for a follow-up examination in 1976. In this group the primary dislocation evaluated in the pre-reduction radiogram as the maximum angulation in either antero-posterior or lateral films of the forearm averaged of radius and ulna was $28 \pm 12°$. In addition, in six of these patients there was an obvious *ad latem* dislocation of one or both bones. Rotational displacement was estimated on the same films from the alignment of the radius and from possible differences in the width of the shaft of the radius immediately proximal and distal to the fracture (Evans 1951). Only in two cases was there a noticeable rotational malposition. Closed reduction had been used in all instances.

The age at fracture was 8 ± 3 years and the age at follow-up 27 ± 4. The shortest interval was 16 years.

The follow-up included a clinical and radiological examination. Any complaints of the patient were recorded and the pronation-supination was measured in a specially designed cradle in which the patient turned a handle with his elbow in a fixed position. The precision of this

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SURGICAL MANAGEMENT OF FRACTURE OF THE CAPITULUM HUMERI

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A follow up study of 20 patients operated upon for fracture of the capitulum humeri is reported In 8 cases the fracture fragment was removed while in 12 others open reduction was performed Open reduction gave the best results and is therefore recommended as the treatment of choice

Key words capitellum, capitulum humeri, fracture, treatment

Accepted 23 v 77

Fracture of the capitulum humeri (capitellum) occurs as an alternative injury to fracture of the caput radii as a result of a fall on the outstretched arm It is, however, considerably less common The relative frequencies are reported to be 1 6 (MacDonald & MacGoey 1959, Palmer 1961) Opinions on the preferred surgical management of this injury differ Some (Gejrot 1932, Rhodin 1942, Watson-Jones 1955) recommend reduction of the dislocated fragment Others (Smith 1954, Bohler 1956, Judet & Raynal 1957, Fowles & Kassab 1974, Alvarez et al 1975) believe removal of the fragment to be the best treatment The present report evaluates and compares the results of these two alternative methods of treatment

MATERIAL AND METHODS

The material consists of 20 consecutive patients operated upon for fracture of the capitellum at St Goran s Hospital or Södersjukhuset, Stockholm during the period 1966-1972 Of these 15 were women and 5 men who at the time of accident could be divided into the following age groups 20 29 years one patient, 30-39, three 40-49, five 50-59, three, and 60-69, eight patients In seven cases only the capitellum or a portion of it was fractured (Type 1) (Figure 1) In the remaining 13 cases the fracture also involved the lateral portion of the trochlea (Type 2) The dislocated fragment always showed a volar and proximal displacement and sometimes a rotation amounting to as much as 90° (Figure 2) Chisel fracture of the capitulum radii occurred as a concomitant injury in three cases All patients were examined by the author personally, and the examination was completed by x-rays of the elbow The observation period was 1-2 years in three cases, 3-4 years in seven, 5-6 years in seven and more than 6 years in three cases

Treatment

In eight cases treatment consisted of removal of the fragment and in twelve cases open reduction was performed In seven of these cases the fragment was fixed with a Palmer pin and in the other five there was no internal fixation (Table 1) All operations were performed at the acute stage (within 10 days after accident) except in one case, which was first operated upon 1 year after injury, with extirpation of the fragment

In those cases in which the fracture fragment was removed, active physiotherapy was begun immediately The remainder were immobilized in plaster casts for 1-4 weeks postoperatively after which physiotherapy was begun

be measured on the radiograms between fracture and non-fracture forearms (Table 2) It must therefore be concluded that the fracture had not changed the shape of the two forearm bones The difference in the range of pronation and supination movement between the fracture and the control forearms was not related to the initial angulation or to whether or not there had been an initial *ad latem* dislocation Also, limitation of pronation and supination was unrelated to the age at the time of fracture In the two cases with rotational malposition the pronation and supination was decreased by 10° in one and by more than 15° in the other as compared with the uninjured side

Table 2 Angulation difference between fractured and non-fractured forearms

	Radius	Ulna
Anteroposterior	0 4° ± 2 9°	0 1° ± 3 1°
Lateral	0 3° ± 4 9°	–1 4° ± 2 6°

One patient, a 26-year-old man, had sustained a fracture of the distal third of the diaphysis of the radius and the ulna at the age of 9 and a primary angulation of about 30° had been reduced completely There were no radiological signs of deformity whatsoever at the time of follow-up Nevertheless, this patient had a limitation of his range of motion of 120° and was the only patient to complain of residual symptoms

DISCUSSION

The clinical findings in this study agree with those of Hogstrom et al (1976) in that even patients with a decrease in the range of pronation–supination motion of 50° had not noticed their dysfunction This might be the reason why this has not been observed in the past Högstrom et al (1976) found a limitation of pronation and supination of about 25° following forearm fractures which had healed with a residual angulation of on the average 20° In the present study the limitation of pronation and supination recorded at follow-up was almost as much This implies that the contribution to this dysfunction of angulation of the two bones is of minor importance since completely reduced forearms which had healed *without any malposition* whatsoever still have a measurable and significant limitation of their range of pronation–supination motion The importance of rotational deformity, however, could not be studied in this series since only two cases had been reduced with a *noticeable residual rotational malposition*

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SURGICAL MANAGEMENT OF FRACTURE OF THE CAPITULUM HUMERI

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A follow-up study of 20 patients operated upon for fracture of the capitulum humeri is reported In 8 cases the fracture fragment was removed while in 12 others open reduction was performed Open reduction gave the best results and is therefore recommended as the treatment of choice

Key words capitellum, capitulum humeri, fracture; treatment

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Fracture of the capitulum humeri (capitellum) occurs as an alternative injury to fracture of the caput radii as a result of a fall on the outstretched arm It is, however, considerably less common The relative frequencies are reported to be 1 6 (MacDonald & MacGoey 1959, Palmer 1961) Opinions on the preferred surgical management of this injury differ Some (Gejrot 1932, Rhodin 1942, Watson-Jones 1955) recommend reduction of the dislocated fragment Others (Smith 1954, Bohler 1956, Judet & Raynal 1957, Fowles & Kassab 1974, Alvarez et al 1975) believe removal of the fragment to be the best treatment The present report evaluates and compares the results of these two alternative methods of treatment

MATERIAL AND METHODS

The material consists of 20 consecutive patients operated upon for fracture of the capitellum at St Goran's Hospital or Sodersjukhuset, Stockholm during the period 1966–1972 Of these 15 were women and 5 men who at the time of accident could be divided into the following age groups 20 29 years one patient, 30–39, three 40-49, five, 50–59, three, and 60–69, eight patients In seven cases only the capitellum or a portion of it was fractured (Type 1) (Figure 1) In the remaining 13 cases the fracture also involved the lateral portion of the trochlea (Type 2) The dislocated fragment always showed a volar and proximal displacement and sometimes a rotation amounting to as much as 90° (Figure 2) Chisel fracture of the capitulum radii occurred as a concomitant injury in three cases All patients were examined by the author personally, and the examination was completed by x rays of the elbow The observation period was 1–2 years in three cases, 3–4 years in seven, 5–6 years in seven and more than 6 years in three cases

Treatment

In eight cases treatment consisted of removal of the fragment and in twelve cases open reduction was performed In seven of these cases the fragment was fixed with a Palmer pin and in the other five there was no internal fixation (Table 1) All operations were performed at the acute stage (within 10 days after accident) except in one case, which was first operated upon 1 year after injury, with extirpation of the fragment

In those cases in which the fracture fragment was removed, active physiotherapy was begun immediately The remainder were immobilized in plaster casts for 1–4 weeks postoperatively after which physiotherapy was begun

be measured on the radiograms between fracture and non-fracture forearms (Table 2). It must therefore be concluded that the fracture had not changed the shape of the two forearm bones. The difference in the range of pronation and supination movement between the fracture and the control forearms was not related to the initial angulation or to whether or not there had been an initial *ad latem* dislocation. Also, limitation of pronation and supination was unrelated to the age at the time of fracture. In the two cases with rotational malposition the pronation and supination was decreased by 10° in one and by more than 15° in the other as compared with the uninjured side.

Table 2. Angulation difference between fractured and non fractured forearms

	Radius	Ulna
Anteroposterior	0.4° ± 2.9°	0.1° ± 3.1°
Lateral	0.3° ± 4.9°	–1.4° ± 2.6°

One patient, a 26-year-old man, had sustained a fracture of the distal third of the diaphysis of the radius and the ulna at the age of 9 and a primary angulation of about 30° had been reduced completely. There were no radiological signs of deformity whatsoever at the time of follow-up. Nevertheless, this patient had a limitation of his range of motion of 120° and was the only patient to complain of residual symptoms.

DISCUSSION

The clinical findings in this study agree with those of Hogstrom et al. (1976) in that even patients with a decrease in the range of pronation–supination motion of 50° had not noticed their dysfunction. This might be the reason why this has not been observed in the past. Hogstrom et al. (1976) found a limitation of pronation and supination of about 25° following forearm fractures which had healed with a residual angulation of on the average 20°. In the present study the limitation of pronation and supination recorded at follow-up was almost as much. This implies that the contribution to this dysfunction of angulation of the two bones is of minor importance since completely reduced forearms which had healed without any malposition whatsoever still have a measurable and significant limitation of their range of pronation–supination motion. The importance of rotational deformity, however, could not be studied in this series since only two cases had been reduced with a noticeable residual rotational malposition.

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showed excellent or good results In six type 2 fractures treated with open reduction results were excellent in two cases, good in two and poor in two cases In all cases of excellent results exact anatomical position was achieved In seven type 2 fractures treated with removal of the fragment results were good in four and poor in three cases

Table 2 Results related to treatment and type of fracture

		Excellent	Good	Poor	Total
Removal of fragment	Type 1	0	1	0	1
	Type 2	0	4	3	7
Open reduction	Type 1	3	3	0	6
	Type 2	2	2	2	6
Total		5	10	5	20

Three patients were reoperated with excision of the radial head ½–1 year after the first operation because of severely impaired mobility Two of these were originally treated by removal of the loose fragment and one by reduction After reoperation the range of movement improved but all three remained in the poor result' group X ray examination showed that in the majority of cases, regardless of treatment, there was some deformation of the capitellum In none of the cases, however was there any loose body in the joint or signs of secondary osteoarthritis

DISCUSSION

This investigation shows that reduction of the fracture gives good results provided that a good anatomical position is achieved This was the case in all five patients in the excellent group It was suggested by Smith (1954) and Judet & Raynal (1957) that reduction of the fracture may result in avascular necrosis and secondary osteoarthrosis No signs of complications of this type were seen in any of the cases in this study

In nearly half of the cases the fracture was so stable after reduction that internal fixation proved unnecessary No postoperative redislocation occurred

Some authors (Rhodin 1942, Watson-Jones 1955, Bohler 1956) claim that closed reduction should always be tried first An attempt at closed reduction was made in three cases in this series, but without success If a good functional result depends on exact reduction, then open reduction would seem to be a better and safer method

After extirpation of the fracture fragment a raw bone surface remains, which according to Watson-Jones (1955) tends to lead to capsular adhesions and restricted mobility In this investigation all eight patients treated in this manner had restricted mobility However, Alvarez et al (1975) and others reported good results with this method In those cases where an exact reduction is not achieved or where the fracture is comminuted, it is better to remove the fragment or fragments Smith (1954) and others claim that there is a risk of lateral instability and a tendency to subluxation following removal of the fragment in fractures of type 2 In the present series all elbow joints were stable at follow-up, so that this risk seems to be small

Johansson (1962) found rupture of the ulnar collateral ligament in 8 out of 13 cases of fracture of the capitellum In the present material the ulnar collateral ligament was explored in one case because of instability and swelling and a total rupture was found and sutured It is probable that restricted mobility following fracture of the capitellum is partly dependent on the extent of concomitant capsule and ligament injuries

The results of the present investigation clearly indicate that open reduction of fracture of the capitulum humeri is a

Table 1 Treatment related to type of fracture

	Type 1	Type 2	Total
Removal of fragment	1	7	8
Open reduction + internal fix	2	5	7
Open reduct without int fix	4	1	5
Total	7	13	20

RESULTS

The majority of patients were pain-free or had only insignificant pain and evaluation of the results was therefore based on limitation of movement The results were classified as follows *Excellent* completely normal mobility without any subjective discomfort *Good* limitation of extension not exceeding 30° and/or a range of flexion of at least 120°, normal pronation and supination *Poor* limitation of mobility exceeding the above and/or restriction of pronation and supination

The results are summarized in Table 2 Six out of seven type 1 fractures were treated with open reduction They all

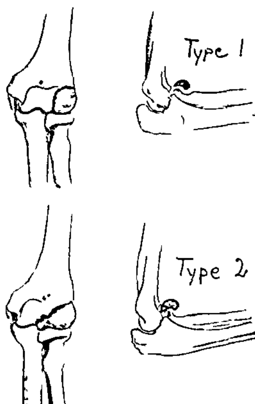


Figure 1 Types of fracture of capitulum humeri Type 1 involves the capitulum only Type 2 includes also part of the trochlea

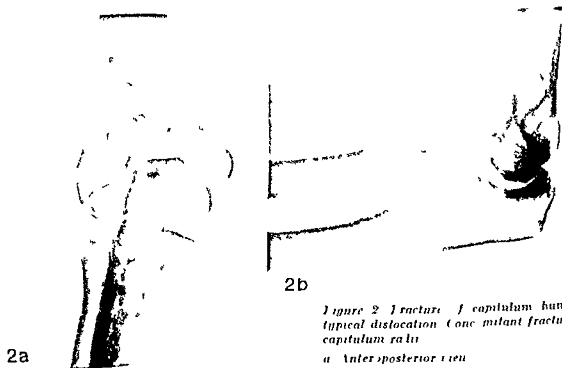


Figure 2 Fracture of capitulum humeri with typical dislocation Concomitant fracture of capitulum radii

a Antero-posterior view
b Lateral view

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RESECTION OF THE ACROMION IN THE TREATMENT OF PERSISTENT ROTATOR CUFF SYNDROME OF THE SHOULDER

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Partial or complete excision of the acromion was performed in 25 patients (29 shoulders) with long standing pain in the shoulder typical of rotator cuff syndrome. There was no verified history of trauma in nine cases (13 shoulders), while injury was the cause of pain in 16 patients (16 shoulders). In nine shoulders there was a small and in two a large rupture of the rotator cuff. Twelve of the 13 non-traumatic shoulders became painless postoperatively and the pain was relieved in one. In the 16 traumatic shoulders the relief of pain was complete in six, partial in nine, and one remained unchanged. The condition was not aggravated in any of the cases. Mobility increased postoperatively in four cases and was in no case decreased by the operation. In this series the results were as favourable after partial as after complete excision of the acromion. Excision of the acromion alone or excision in combination with other procedures appears to be a promising method of treatment of patients with long standing rotator cuff syndrome.

Key words: acromion resection, supraspinatus syndrome, rotator cuff syndrome, painful arch syndrome, shoulder pain

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The majority of patients with rotator cuff (supraspinatus, painful arch, impingement) syndrome of the shoulder recover either spontaneously or after conservative treatment. Patients with persistent pain have been operated upon applying various methods, e.g., partial (Smith-Petersen et al. 1943, Darrach 1945, Neviaser 1961, Neer 1972) or complete excision of the acromion (Watson-Jones 1943, Armstrong 1949, Rossler 1959, Rose 1961, Hammond 1962, Sik 1964).

The aim of this study was to investigate the importance of the extent of excision of the acromion because the literature is somewhat controversial on this subject. We also wanted to find out how the rotator cuff syndrome of different aetiologies and the mobility of the shoulder affected the results of the operation.

MATERIAL

The series consists of 25 patients with 29 shoulders with rotator cuff syndrome, operated upon at the Orthopaedic Hospital of the Invalid Foundation, Helsinki, during the period 1958–1970. The patients' ages at the time of operation ranged from 30 to 64 years, the average being 50 years. Of the non traumatic cases five were female and four male, of the traumatic cases four were female and 12 male. The right shoulder only was affected in 14 cases, the left shoulder in seven and both shoulders in four (Table 1) and only one patient was left handed.

better method of treatment than removal of the loose fragment

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Table 5 Results after excision of the acromion in relation to pain in the various categories of injury in the traumatic group

Trauma and peroperative findings	Results				
	Painless	Improved	Unchanged	Impaired	Total
Partial rupture of supraspinatus only	2	3	1	–	6
Partial rupture of supraspinatus + rupture of the long head of m biceps	–	1	–	–	1
Dislocation of humerus + total supraspinatus rupture	1	1	–	–	2
Dislocation of humerus without visible rupture of tendons		1	–	–	1
Dislocation of acromioclavicular joint	1		–	–	1
War injury, shell splinters		1	–	–	1
Miscellaneous cases without injury to tendons	2	2	–	–	4
Total	6	9	1	–	16

its in the musculotendinous cuff in eight non traumatic and two traumatic shoulders Acromioclavicular arthrosis was clearly present in three shoulders one non traumatic and two traumatic Dislocation of the acromioclavicular joint was observed in one shoulder

Rotator cuff rupture During the operation a small rupture of the rotator cuff was observed in nine shoulders two non traumatic and seven traumatic A large rupture was found in two out of three shoulders that had become painful after dislocation of the humerus

Operative procedure The excision of the acromion was performed in sagittal projection, and complete excision (including the acromioclavicular joint) was performed in six shoulders subtotal excision in two and partial excision in 21 (Tables 3 and 4) In nine out of the 11 shoulders with a rotator cuff tear this was repaired during operation in three the tendon was fixed by sutures to the tuberculum majus humeri and in the remainder the tendon defect was merely sutured as well as possible to diminish the defect The detached part of the deltoid muscle was refixed by sutures to the clavicula and the rest of the acromion

Postoperative care After the operation three extremities only were fixed in an abduction splint for about 2 weeks the others were supported in a collar sling Passive movements were usually begun during the first week postoperatively and the active exercises thereafter

RESULTS

Pain Twelve of the 13 non-traumatic shoulders became painless postoperatively and the pain was considerably relieved in one (Table 3) In the 16 traumatic shoulders the relief of pain was complete in six and marked in nine, while one remained unchanged (Tables 4 and 5) No aggravation was recorded in this series Of the two patients with no tendon suture in connection with the acromion excision one was painless and the other was improved and of the nine patients with tendon sutures four were painless, four others improved and one unchanged

Mobility Postoperatively the range of movement was normal in 12 non-traumatic shoulders and slightly reduced in one (i e , one improved, 12 unchanged)

Table 1 Side of operated shoulder in relation to aetiology (no of patients)

Side	Aetiology Non traumatic	Traumatic	Total
Left	1	6	7
Right	4	10	14
Bilateral	4	–	4
Total	9	16	25

Table 2 Duration of pain before operation in relation to aetiology

	Aetiology Non traumatic	Traumatic
Duration in years	½–6	½–17
Average	2 7	3 6

Pain in the shoulder had been experienced for a period of from half a year to 17 years the average being 3 3 years (Table 2) The majority of the patients had been conservatively treated (physiotherapy cortisone injections local anaesthetics X ray treatment) without success The pain in the shoulder was in all cases accentuated on flexion and abduction of the humerus

A follow up examination was performed 3 5–15 years (average 6 5 years) after operation There was no history of injury in nine cases (13 shoulders) while it was obvious that the pain had been caused by trauma in 16 cases (16 shoulders) In the latter group there were three cases of dislocation of the shoulder joint and one case of acromioclavicular dislocation One patient had a history of slight shell splinter injury (Table 5)

Of the non traumatic patients six had light two moderate and one heavy physical work of the patients with trauma three had light six moderate and seven heavy physical work

Preoperative clinical findings In the non traumatic group the range of passive and active movement was normal before operation in 11 shoulders and somewhat reduced in two (Table 6) In the traumatic group the range of movement was normal in seven shoulders slightly reduced in two and markedly reduced in seven (Table 7) In the majority of patients with limitation of shoulder movement active abduction and flexion were the most affected

Preoperative X rays revealed calcified depos

Table 3 Results in relation to pain and extent of excision of the acromion in non traumatic cases (no of shoulders)

Extent of excision of acromion	Results Painless	Improved	Unchanged	Impaired	Total
Partial	11	1			12
Subtotal	1				1
Complete					–
Total	12	1			13

Table 4 Results in relation to pain and extent of excision of the acromion in traumatic cases (no of shoulders)

Extent of excision of acromion	Results Painless	Improved	Unchanged	Impaired	Total
Partial	3	6			9
Subtotal	1				1
Complete	2	3	1		6
Total	6	9	1		16

Table 5 Results after excision of the acromion in relation to pain in the various categories of injury in the traumatic group

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	Painless	Improved	Unchanged	Impaired	Total
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Partial rupture of supraspinatus + rupture of the long head of m biceps	–	1	–	–	1
Dislocation of humerus + total supraspinatus rupture	1	1	–	–	2
Dislocation of humerus without visible rupture of tendons	–	1	–	–	1
Dislocation of acromioclavicular joint	1	–	–	–	1
War injury, shell splinters	–	1	–		1
Miscellaneous cases without injury to tendons	2	2	–	–	4
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Operative procedure The excision of the acromion was performed in sagittal projection, and complete excision (including the acromioclavicular joint) was performed in six shoulders, subtotal excision in two and partial excision in 21 (Tables 3 and 4) In nine out of the 11 shoulders with a rotator cuff tear, this was repaired during operation in three the tendon was fixed by sutures to the tuberculum majus humeri and in the remainder the tendon defect was merely sutured as well as possible to diminish the defect The detached part of the deltoid muscle was refixed by sutures to the clavicula and the rest of the acromion

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Mobility Postoperatively the range of movement was normal in 12 non-traumatic shoulders and slightly reduced in one (i e, one improved, 12 unchanged)

Table 6 Results in relation to mobility of the shoulder before and after excision of the acromion in the non-traumatic group (no of shoulders)

	Mobility			Total
	Normal	Slightly reduced	Markedly reduced	
Before operation	11	2	–	13
After operation	12	1	–	13

Table 7 Results in relation to mobility of the shoulder before and after excision of the acromion in the traumatic group (no of shoulders)

	Mobility			Total
	Normal	Slightly reduced	Markedly reduced	
Before operation	7	2	7	16
After operation	9	3	4	16

(Table 6) In the traumatic group the range of movement was normal postoperatively in nine shoulders, slightly reduced in three and markedly reduced in four (i e, three improved, 13 unchanged) (Table 7) Thus the operation resulted in increased mobility in four shoulders and in no case was the range of movement further decreased by the operation

In this series the extent of the excision of the acromion did not influence the occurrence of pain nor the mobility of the shoulder (Tables 3 and 4)

There was no definite correlation between the age of the patient and the duration of the symptoms before operation and the results

There was no dislocation or subluxation of the glenohumeral joint postoperatively in our series

DISCUSSION

The aetiology and the mechanism of pain in the shoulder are not fully understood A number of investigations (Codman 1934, Watson-Jones 1943, Wilson 1943, McLaughlin 1944, 1946, 1954, Armstrong 1949, Hammond 1962, Moseley 1969, Macnab 1971) have shown that a lesion of the tendon of the supraspinatus muscle or some other muscle belonging to the rotator cuff system may lead to the typical condition, the painful arch (supraspinatus) syndrome, which is characterized by pain, tenderness on palpation, muscle spasm and limitation of shoulder movement The pain is usually elicited by activity or compression of the rotator cuff Abduction and flexion of the humerus, in particular, often lead to painful compression of the rotator cuff between the head of humerus, the acromion and the acromioclavicular ligament Excision of the acromion eliminates the compression of the rotator cuff caused by movements of the shoulder joint Many authors consider complete excision of the acromion necessary to ensure successful results and to eliminate the risk of recurrence The importance of excision of the anterior edge and undersurface of the anterior part of the

acromion which may cause impingement on the tendinous portion of the rotator cuff has been emphasized (Neer 1972). In the present series the results were as favourable after partial as after complete excision of the acromion. As regards the relief of pain the results were generally good and the condition was not aggravated postoperatively in any of the cases. Mobility was also improved after operation in some of the cases and there was no instance of postoperative impairment of mobility. In our series there was no dislocation and subluxation of the shoulder after the operation. Subsequently we have seen two other cases with a tendency to subluxation of the humeral head during normal activities after complete excision of the acromion. In these cases there was a large rupture of the capsule and of the rotator cuff, both of which were not adequately reconstructed. It is probably important to reconstruct these structures and if they are still insufficient the acromion should not be excised completely.

Most patients with pain in the shoulder, particularly those with the supraspinatus syndrome, recover spontaneously or after physiotherapy. In the treatment of persistent symptoms of the supraspinatus group excision of the acromion appears to be a promising alternative.

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EXTIRPATION OF TUMORS LOCATED NEAR THE THORACIC CAGE

A Method for Increasing the Margin of Healthy Tissue on the Deep Side of the Tumor

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When an aggressive tumor develops in a flat muscle near the thoracic cage the question may arise as to how achieve an adequate margin on the deep side of the tumor This is especially the case if the tumor has recurred after a previous non radical operation A method is described by which the external thoracic fascia, the external intercostal musculature, and the periosteum on the external surface of the ribs can be included in the specimen as a continuous wall of healthy tissue on the deep side of the tumor This technique has been used in 11 patients, 9 of whom had undergone one or more inadequate operations earlier Eight patients had a malignant tumor, three an extra abdominal desmoid In one of the latter patients, in whom a recurrent tumor was adherent to rib periosteum the method was unsuitable In the other patients the method appears to have been adequate for local control of the tumor

Key words chest wall, four quarter amputation, operative technique, soft tissue neoplasm, surgical treatment, thoracic neoplasms

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Malignant soft tissue tumors must be removed with a margin of healthy tissue on all sides The quality of the margin decides how wide it must be A tumor originating in a muscle tends to get an elongated shape growing as it does preferentially in the direction of the muscle fibers Therefore, in the longitudinal planes of the muscle, the margin must be very wide, which often means removal of the whole muscle In the transverse planes the margin need not be as wide providing the preformed fascial confinement of the tumor-bearing region is included in the specimen (Stener 1971) Even malignant soft tissue tumors tend to respect preformed fibrous walls for a long time (Simon & Enneking 1976).

Tumors located near the thoracic cage present special problems For radical removal of a tumor developed for instance in one of the broad muscles originating on ribs and inserting on the upper limb it may not be sufficient to excise the implicated muscle, including its fascia There is often a need for increasing the margin of healthy tissue being removed on the deep side of the tumor This is especially the case if the tumor has recurred after a non radical earlier operation

The purpose of this paper is to describe

a method by which the external thoracic fascia, the external intercostal musculature, and the periosteum on the external surface of the ribs can be included in the specimen as a continuous wall of healthy tissue on the deep side of the tumor

ANATOMY

The following description of relevant anatomical details is based mainly on Grant's Atlas of Anatomy (1962)

The thoracic cage is covered by the external thoracic fascia which extends from one rib to the next The intercostal musculature can be divided into three layers (Figure 1) The *most superficial* consists of the external intercostal muscle (1) which extends from the costotransverse joints in the back to the costochondral junction in the front where it is replaced by the external intercostal membrane (2) The fibers of this muscle and membrane are directed obliquely downwards forwards The *middle* layer consists of the internal intercostal muscle (3) which extends from the sternum in the front to the junction of the middle and posterior thirds of the ribs in the back, where it is replaced by the internal intercostal membrane (4) The fibers of this muscle and membrane are directed obliquely downwards backwards The *deepest* layer consists of the innermost intercostal muscle (5) which extends from the junction of the anterior and middle thirds of the ribs in the front to the angle of the ribs in the back The fibers of the innermost intercostal muscle are directed obliquely downwards-backwards The intercostal nerves and vessels run between the middle and the deepest layers where the latter is lacking they run close to the pleural membrane

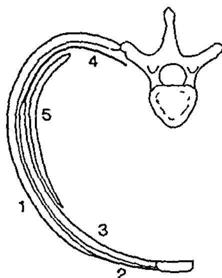


Figure 1 Schematic drawing representing the constituents of the three layers of intercostal structures 1 = external intercostal muscle 2 = external intercostal membrane 3 = internal intercostal muscle 4 = internal intercostal membrane 5 = innermost intercostal muscle

METHOD

When the thoracic cage has been exposed during the operation at a safe distance from the tumor the dissection is continued as illustrated in Figure 2 The periosteum of the rib chosen as the starting point for the dissection is incised along the border being most remote from the tumor site It is then elevated as far as the insertion line of the external intercostal muscle and membrane on the opposite border Once this muscle and membrane have been detached subperiosteally from the rib they are separated from the internal intercostal muscle and membrane as far as the next rib where they are again detached subperiosteally The dissection is then carried on in this manner from rib to rib until the tumor region has been safely passed In this way the external thoracic fascia the external intercostal musculature and the periosteum on the external surface of the ribs will be included in the specimen as a continuous wall of healthy tissue on the deep side of the tumor

The separation of the external intercostal muscle and membrane from the internal ones is facilitated by the different fiber directions of these muscles and membranes Because the fibers of the external intercostal muscle and membrane are directed obliquely downwards forwards It is convenient when detaching this muscle and membrane from their rib insertions

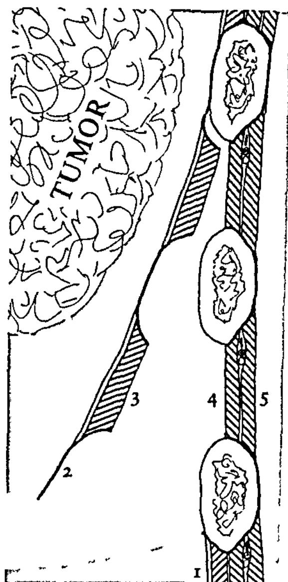


Figure 2 Schematic drawing demonstrating the method described for increasing the margin of healthy tissue being removed on the deep side of a tumor located near the thoracic cage 1 = external thoracic fascia 2 = periosteum of rib 3 = external intercostal muscle 4 = internal intercostal muscle 5 = innermost intercostal muscle

to proceed from behind forwards along the superior border of the rib and in the opposite direction along the inferior border When making this dissection in the back it should be remembered that medial to the angle of the ribs where the innermost intercostal muscle is lacking the pleura comes next to the internal intercostal membrane

CLINICAL MATERIAL

Since 1969 the technique described has been used for extirpation of a soft tissue tumor in 11 patients (Table 1) Their age ranged from 25 to 73 years Eight patients had a malignant tumor three a locally aggressive tumor (extra abdominal desmoid) Nine patients had undergone one or more non radical operations for the tumor before admission Aspiration biopsy had indicated malignancy in the other two None had signs of metastatic spread before operation

The follow up time varied between 12 and 8? months in nine patients, the remaining two were operated upon recently

One patient (Case 3), operated upon for a recurrent malignant fibroxanthoma in the left axilla (extended interthoracoscapular amputation) died after 15 months with pulmonary metastases, but the surgical field remained free from tumor

One patient (Case 6), operated upon after a non radical removal of a malignant giant cell tumor of soft parts in the back (operation similar to that illustrated below in Case 8) was apparently free from tumor at follow up but has later developed pulmonary metastases

One patient (Case 4), operated upon for a recurrence of an extra abdominal desmoid below the left axilla adherent to ribs developed a new local recurrence after 30 months A resection of the thoracic wall including the implicated ribs was then carried out and at follow up 27 months after this operation the patient showed no signs of recurrence

The remaining six patients followed up were all well without any signs of recurrence or metastatic spread

ILLUSTRATIVE CASES

Case 8 A 64 year old man had noticed a rapidly growing mass below the right scapular angle at the level of the eleventh rib Under local anesthesia a tumor measuring 6 × 4 × 3 cm was enucleated from the latissimus dorsi muscle As it proved to be a pleomorphic liposarcoma the patient was referred for radical excision of the tumor region

A rectangular incision of the skin was made at a minimum distance of 2 5 cm from the scar of the previous operation and two semicircular auxilliary incisions were made for wide exposure of the tumor region and to permit later on, primary suture of the wound without undue tension (Figure 3 A) The specimen removed in one piece comprised the excised skin with underlying and surrounding subcutaneous fat

Table 1 Summary of clinical data on eleven patients operated upon using the described technique

Case no	Age	Sex	Histologic type	Site	Period of follow up (months)	Previous surgery	Aspiration biopsy	Local recurrence	Metastasis
1	60	Male	Extra abdominal desmoid	Pectoralis minor	82	–	+	—	—
2	41	Male	Pleomorphic liposarcoma	Pectoralis major	82	+	—	—	—
3	33	Male	Malignant fibroxanthoma	Latissimus dorsi	15 (died)	+	—	—	+
4	53	Male	Extra abdominal desmoid	Serratus anterior	57	+	—	+	—
5	25	Female	Extra abdominal desmoid	Pectoralis major	31	+	—	—	—
6	33	Male	Malignant giant cell tumor of soft parts	Latissimus dorsi	24	+	—	—	+
7	49	Male	Lipoma like liposarcoma	Latissimus dorsi	13	+	—	—	—
8	64	Male	Pleomorphic liposarcoma	Latissimus dorsi	12	+	—	—	—
9	73	Female	Malignant mesenchymoma	Erector spinae	12	–	+	—	—
10	54	Male	Malignant Schwannoma	Plexus axillaris	1	+	—	—	—
11	59	Male	Myxoid and lipoma like liposarcoma	Between latissimus dorsi and serratus anterior	1	+	—	—	—

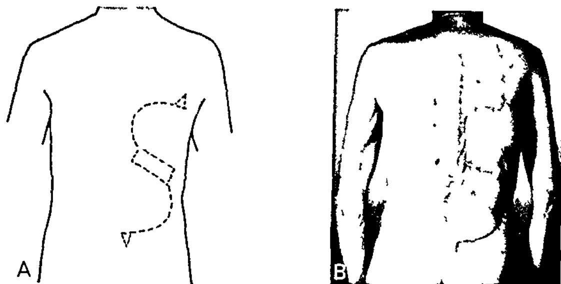


Figure 3 Case 8 A Skin incisions See text B Patient 6 months after operation

(Figure 4 C), the latissimus dorsi the serratus posterior inferior, the quadratus lumborum most of the erector spinae and some of the abdominal muscles and the periosteum of the four lowest ribs in continuity with the interlying external intercostal muscles (Figure 4 D) Figure 4 A shows the surgical field after removal of the specimen Before the large S formed wound (Figure 4 B) was sutured a small triangle of skin was excised at its upper and lower ends

Histologic examination revealed that the specimen contained remnants of the tumor within the earlier operation field which however had been removed with an adequate margin of healthy tissue on all sides

At follow up 1 year after operation the patient was well without any signs of recurrence or metastases The wound had healed nicely (Figure 3 B) He was not inconvenienced by the loss of musculature

Comment

In this case posteriorly the external intercostal muscles were separated from the internal intercostal membranes (cf Figure 1) Medial to the angle of the ribs care had to be taken not to damage the pleura underneath these membranes An almost identical operation in the same region was done in Case C

Case 9 A 73 year old woman had for a few weeks noticed a firm painless mass in her back On examination an elongated tumor whose size was estimated to be 13 × 9 × 5 cm was found It was located between the medial border of the left scapula and the spine The long axis of the tumor had the same direction as the erector spinae muscle Aspiration biopsy revealed a malignant mesenchymal tumor A radical extirpation was planned

The incision of the skin and the subcutaneous fat was made so that the biopsy track became included in the specimen with an ample margin When the trapezius, the rhomboidei and the upper part of the latissimus dorsi muscles had been detached from the spinous processes it became clear that the tumor was free from the ribs it appeared to have developed primarily in the erector spinae This muscle was widely excised along with on the posterior side subcutaneous fat parts of the trapezius rhomboideus major and latissimus dorsi muscles on the anterior side, the periosteum of four ribs in continuity with the interlying external intercostal muscles, and on the anteromedial side vertebral periosteum including the posteriorly protruding part of the left transverse process of three vertebrae (Figure 5 C) Figure 5 A shows the surgical field after removal of the specimen the deep side of which is shown in Figure 5 B The tumor which was never exposed during the operation had been removed with an adequate margin of healthy tissue on all sides as revealed by serial sectioning of the specimen (Figure 5 D) The histopathologic diagnosis was malignant mesenchymoma

At follow up 1 year after operation the patient was well without any signs of recurrence or metastases

Comment

This case illustrates how the described method of including rib periosteum and external intercostal muscles in a tumor specimen can be combined with inclusion of vertebral periosteum and

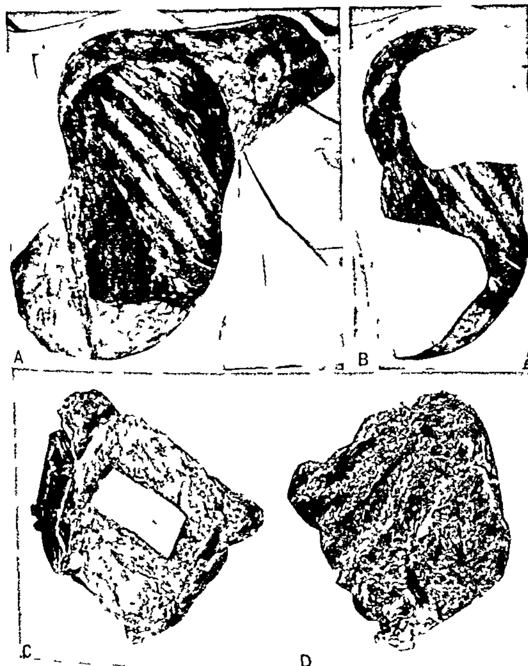


Figure 4 Case 8 Surgical field after removal of specimen (A) and before closure of wound (B) The specimen included a rectangular area of skin containing the scar with suture tracks after previous surgery (C) and on the deep side the periosteum of the four lowest ribs in continuity with the underlying external intercostal muscles (D)

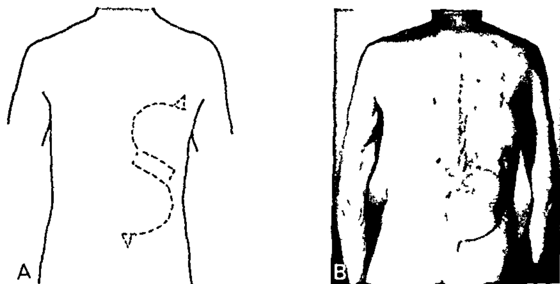


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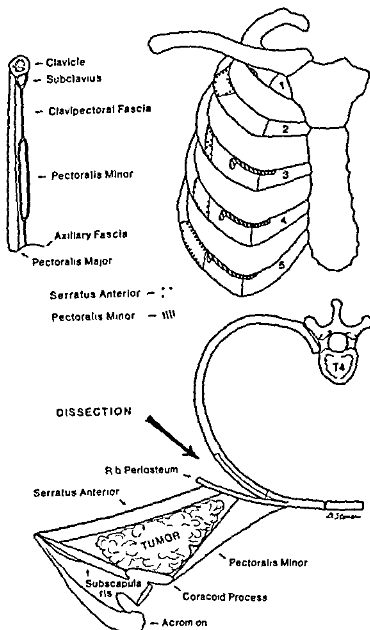


Figure 6 Case 10 Schemat c drawings illustrating principle behind exten led interthoracoscapular amputati n (alm st completed in bottom figure) Rib peri steum in c ntinuity with the external th racic fascia an l external interc stal muscles is being included in the specimen within the fiel l where the serratus anteri r an l the clavipectoral fascia (top left) inclu ling the subclavicus and pect ral s minor are attache l to the thoracic wall (top right) The ro m in which the tumor grows will thereby l e remove l unopene l (cf rib 4 in t p right and b tt m figures)

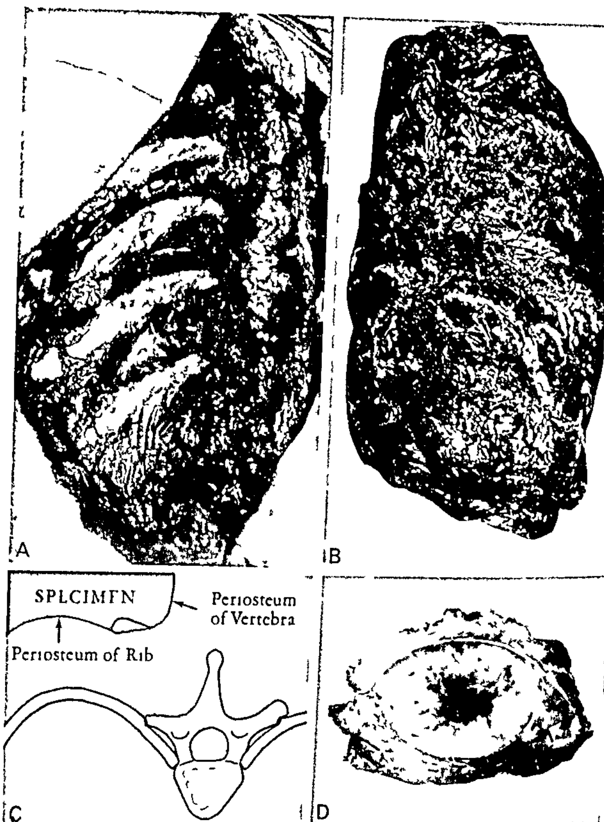


Figure 5. Case 9. A. Surgical field after removal of specimen. B. D[illegible] of specimen. C. Schematic drawing showing that the specimen included costal and vertebral periosteum and the posteriorly protruding part of the left transverse vertebral processes. D. Transection of specimen. Deep margin bottom, medial margin right. Arrow indicates border between tumor and erector spinae.

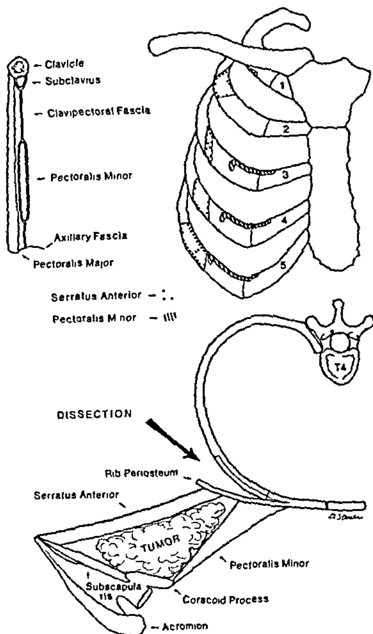


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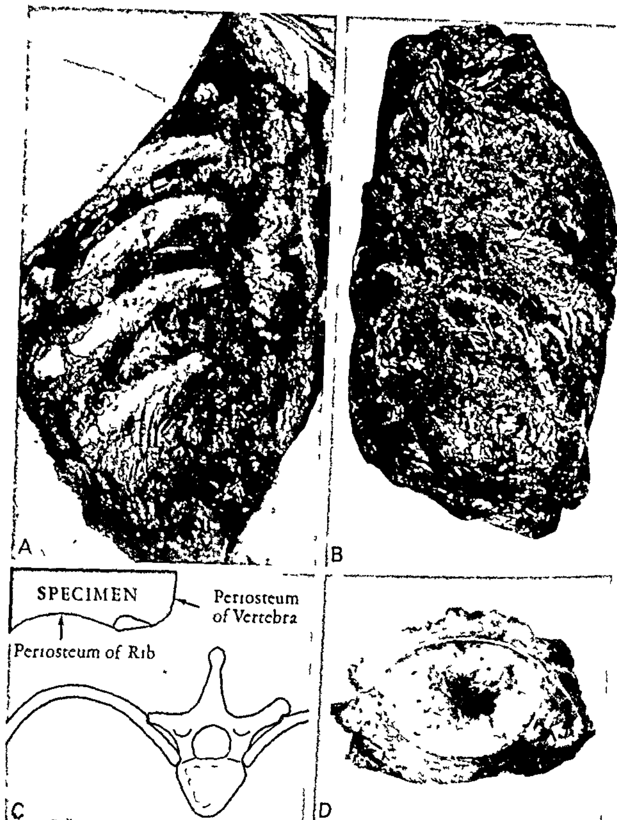


Figure 5 Case 9 A Surgical field after removal of specimen B Deep side of specimen C Schematic drawing showing that the specimen included costal and vertebral periosteum and the posteriorly protruding part of the left transverse vertebral processes D Transection of specimen Deep margin bottom medial margin right Arrow indicates border between tumor and erector spinae

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The technique described should be used only when the tumor is mobile in relation to the ribs The only local recurrence in our series occurred in a patient who underwent the operation for a recurrent extra abdominal desmoid which was adherent to ribs (Case 4) In two patients operated upon for recurrent tumors pulmonary metastases occurred within 2 years but no signs of local recurrence appeared The fact that distant metastases develop does not indict the method used for local control of the tumor as long as the primary site remains free from recurrence (Bowden & Booher 1958)

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parts of the spine when the location of the tumor calls for this to be done

Case 10 A 54-year-old man was admitted with a large recurrence of a malignant Schwannoma in the right axilla He suffered severe pain and the arm, which was paralysed and edematous, was quite useless Radiotherapy (6000 rad) had been given without much benefit. An extended interthoracoscapular amputation was performed The extension beyond standard is illustrated in Figure 6 Instead of detaching the serratus anterior from the scapula and leaving it with the patient, this muscle was included in the specimen as it constituted the medial wall of the room occupied by the tumor The anterolateral wall of this room was the clavipectoral fascia with the muscles it includes: the subclavius and pectoralis minor (top left in Figure 6), and the posterolateral wall was the subscapularis muscle Between the lines along which the serratus anterior and the pectoralis minor are attached to the thorax (top right in Figure 6) the tumor-containing room was limited directly by the external thoracic fascia with underlying ribs and external intercostal muscles So, in order to remove this room unopened and thereby increase the margin of healthy tissue being included in the specimen, the external thoracic fascia, the periosteum of the first, second, third and fourth ribs, and the external intercostal muscle and membrane of the first, second, third, and fourth intercostal spaces were removed within an area that included the rib attachments of the serratus anterior and pectoralis minor (Figure 7, cf Figure 6 top right) The pectoralis major was also included in the specimen The postoperative course was uneventful, the patient was able to leave the hospital after 4 days

Macro- and microscopic study of the surgical specimen indicated that the tumor had been radically removed

When last seen 1 month after operation, the patient was apparently free from tumor Being a Greek citizen domiciled in Greece, he has not been available for later follow-up examination

Comment

The same type of extended interthoracoscapular amputation was carried out in Case 3 In the standard type of "four quarter" amputation (e g Moseley 1957) the serratus anterior is left with the patient on the thoracic wall This is not adequate when the operation is done for a malignant tumor developing in the axilla, for instance, a leiomyosarcoma originating in the axillary vein or, as in Case 10, a malignant Schwannoma originating in the axillary nerve plexus. In such cases, the whole serratus anterior should be included in the surgical specimen and an extra safety margin is obtained, without significant cost for the patient, by including rib periosteum and external intercostal muscles as described in Figure 6



Figure 7 Case 10 Anterolateral aspect of thoracic wall after extended right interthoracoscapular amputation (cf Figure 6) Horizontal arrows indicate the line anterior to which the external thoracic fascia the periosteum of the four uppermost ribs and the external intercostal muscle and membrane of the four uppermost intercostal spaces have been removed en bloc with the specimen The internal intercostal muscles have been exposed within this area Notice the difference in fiber direction between the external and internal intercostals Vertical arrow indicates the costochondral junction of the third rib (cf Figure 6 top right)

DISCUSSION

The described operative technique is indicated when an aggressive soft tissue tumor (malignant or only locally aggressive) develops within a flat muscle of the thoracic wall, especially if the tumor has

recurred or an extended excision is called for after a previous non radical operation. The same technique can be used for increasing the margin when a four-quarter amputation is done (Cases 3 and 10). Nine of our eleven patients had previously been operated upon, only two underwent a primary operation.

The technique described should be used only when the tumor is mobile in relation to the ribs. The only local recurrence in our series occurred in a patient who underwent the operation for a recurrent extra abdominal desmoid which was adherent to ribs (Case 4). In two patients, operated upon for recurrent tumors, pulmonary metastases occurred within 2 years, but no signs of local recurrence appeared. The fact that distant metastases develop does not indict the method used for local control of the tumor as long as the primary site remains free from recurrence (Bowden & Booher 1958).

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THE ARTERIAL SUPPLY OF THE ODONTOID PROCESS OF THE AXIS

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A study has been carried out of the arterial supply of the odontoid process of the axis. Among the arterial sources there are paired anterior and posterior ascending arteries arising from the vertebral artery. Arteries penetrate into the odontoid process at its base from both the anterior and posterior ascending arteries. A transverse arterial arcade is formed above its top by the anastomosing anterior and posterior ascending arteries. In this investigation it was demonstrated that a branch of the ascending pharyngeal artery (from the external carotid artery) joined this arcade after passing through the canalis hypoglossi of the occipital condyle. Moreover, there were inferior and superior horizontal arteries apparently coming from the internal carotid artery, which supplied the odontoid process. It was shown that the superior horizontal arteries penetrated the anterior atlanto-occipital membrane and ran across to the supraodontoid arterial arcade. There were also arteries which reached into the odontoid process via the accessory and apical ligaments. Vessels described—but not demonstrated—to reach the odontoid process via the alar ligaments could not be observed in this investigation. It was shown that inside the odontoid process the arteries formed a rich anastomosing network. The odontoid process of the axis is thus in the centre of a dense arterial network.

Key words: odontoid process, arterial supply, paired ascending arteries, supraodontoid arterial arcade, intraosseous anastomotic arterial network.

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The odontoid process has a stabilizing effect on the function of the atlanto-axial articulation. This stability is jeopardized in fractures of the odontoid process, but a delayed or failed bony union need not necessarily give rise to any symptoms. Schatzker et al. (1971) have reported a frequency of non-union (pseudarthrosis) in 64 per cent and Blockley & Purser (1956) in 63 per cent. Lower frequencies have been reported by Amyes & Anderson (1956) who found a rate of pseudarthrosis of 5 per cent which was also found by Böhler (1965). There are also reports (Nachemson 1960, Anderson & d'Alonzo 1974) with non-union frequencies of the order of 44 per cent and 26 per cent. The difference between the reported extremes of 64 per cent and 5 per cent appears to be due to the technique of examination which in the high frequency series includes tomography and radiography of the cervical spine in flexion-extension.

The reason for non-union has been debated (Nachemson 1960, Schatzker et al. 1971). It is argued that the vascular supply becomes disturbed to an extent that revascularization does not occur

satisfactorily An impairment in healing follows It has been suggested that in so-called *low fractures, i e, fractures* through the base of the odontoid process, no vital vessels become injured and thus healing occurs uneventfully (Schatzker et al 1971, Bailey 1974) In high fractures however, the large vessels reaching the odontoid process via the accessory ligaments become injured and it has been postulated that this may impair circulation to such an extent that non union of an odontoid fracture ensues Moreover, the opinion has been advanced that the vascular supply to the odontoid process is so poor in general that odontoid fractures consequently heal badly (Schmorl 1971, Bailey 1974) The pertinent problem, therefore, seems to be to analyse in more detail the vascular arrangement of the odontoid and furthermore relate the observations to the most common localizations of odontoid fractures

Therefore the aim of this investigation was

1) *to make a detailed study of the arteries surrounding, penetrating into and running in the odontoid process* and
2) *to produce experimental fractures and* correlate the anatomy of arteries to the fractures obtained This latter part of the investigation will be re*ported separately*

ANATOMY

Embryonal development

Between the twentieth and twenty fourth fetal week two laterally situated ossification centres appear (Figure 1) These unite at birth About 2 years later *an ossification centre* appears on top of the fused lateral centres (Figure 1 Between the odontoid process and the remaining axis there is a cartilage plate which becomes ossified between 10 and 20 years of age In the individual case the cartilage plate may however remain into adulthood

During the second decade there is a fusion of the apical ossification centre with the two lateral

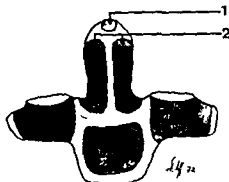


Figure 1 Embryonal development
1 Apical ossification centre
2 Lateral ossification centres

Ligaments

The odontoid process is important for the stability of the atlanto axial articulation Its position in relation to the posterior facet of the anterior part of the atlas is secured by the strong transverse ligament running posterior to the odontoid The accessory ligaments arise from the massa lateralis of the atlas and insert into the lateral aspect of the base of the odontoid process The apical ligament arises from its tip and inserts into the anterior rim of the foramen magnum (Figure 2) There are two more ligaments—the alar— which arise posterolaterally from the odontoid and insert into the occipital condyles

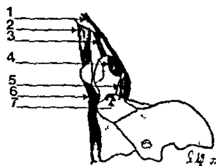


Figure 2 Ligaments around the odontoid process
1 Tectorial membrane
2 Anterior atlanto occipital membrane
3 Apical ligament
4 Alar ligament
5 Transverse ligament
6 Anterior longitudinal ligament
7 Accessory ligament

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THE ARTERIAL SUPPLY OF THE ODONTOID PROCESS OF THE AXIS

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A study has been carried out of the arterial supply of the odontoid process of the axis Among the arterial sources there are paired anterior and posterior ascending arteries arising from the vertebral artery Arteries penetrate into the odontoid process at its base from both the anterior and posterior ascending arteries A transverse arterial arcade is formed above its top by the anastomosing anterior and posterior ascending arteries In this investigation it was demonstrated that a branch of the ascending pharyngeal artery (from the external carotid artery) joined this arcade after passing through the canalis hypoglossi of the occipital condyle Moreover, there were inferior and superior horizontal arteries apparently coming from the internal carotid artery, which supplied the odontoid process It was shown that the superior horizontal arteries penetrated the anterior atlanto-occipital membrane and ran across to the supraodontoid arterial arcade There were also arteries which reached into the odontoid process via the accessory and apical ligaments Vessels described—but not demonstrated—to reach the odontoid process via the alar ligaments could not be observed in this investigation It was shown that inside the odontoid process the arteries formed a rich anastomosing network The odontoid process of the axis is thus in the centre of a dense arterial network

Key words odontoid process, arterial supply, paired ascending arteries, supraodontoid arterial arcade intraosseous anastomotic arterial network

Accepted 27 vii 77

The odontoid process has a stabilizing effect on the function of the atlanto-axial articulation This stability is jeopardized in fractures of the odontoid process, but a delayed or failed bony union need not necessarily give rise to any symptoms Schatzker et al (1971) have reported a frequency of non-union (pseudarthrosis) in 64 per cent and Blockley & Purser (1956) in 63 per cent Lower frequencies have been reported by Amyes & Anderson (1956) who found a rate of pseudarthrosis of 5 per cent which was also found by Bohler (1965). There are also reports (Nachemson 1960, Anderson & d'Alonzo 1974) with non-union frequencies of the order of 44 per cent and 26 per cent The difference between the reported extremes of 64 per cent and 5 per cent appears to be due to the technique of examination which in the high frequency series includes tomography and radiography of the cervical spine in flexion-extension

The reason for non-union has been debated (Nachemson 1960, Schatzker et al 1971) It is argued that the vascular supply becomes disturbed to an extent that revascularization does not occur

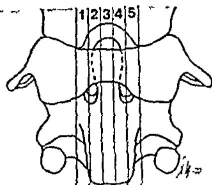


Figure 4 a Longitudinal in sagittal plane

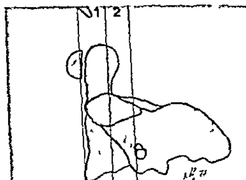


Figure 4 b Longitudinal in frontal plane

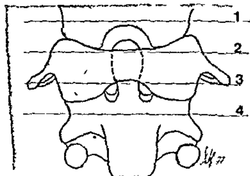


Figure 4 c Transverse in horizontal plane

Figure 4 Sections of axis used for preparation according to the Spalteholtz method

The contrast medium was injected into the common carotid artery and or the vertebral artery Three specimens were injected in both common carotid arteries and both vertebral arteries via four parallel coupled catheters One specimen was filled through one common carotid artery only and two through one common carotid artery and one ipsilateral vertebral artery The injection was stopped when the white contrast medium was seen to appear either in the intercostal arteries or when the skin blanched The filling pressure was that of manual compression of a 10 cm³ injection syringe The filling procedure lasted for some 30 minutes All arteries through which contrast medium leaked were tied Following the filling procedure the cervical column and part of the base of the skull were excised and some contrast medium was seen to disappear from the carotid and vertebral arteries before it had adhered to the vessel walls

The specimens were frozen and once hardened by the freezing procedure they were cut in longitudinal sections in both the sagittal and frontal planes (Figure 4 a b) Horizontal sections (Figure 4 c) were also made Each individual section was then x rayed A particular soft tissue technique also used for mammography was employed (Mammodiagnost, Philips) Film focal distance 30–35 cm exposure 25 kV, 0 2–1 s Kodak film (Industrex C ℞) was used

Following radiography the sections were prepared according to the Spalteholtz technique (Spalteholtz 1914) by which they were made translucent This technique permits a three dimensional study of the course of the arteries

Once prepared by the Spalteholz technique the specimens were x rayed a second time More information regarding the distribution of the arteries was thus obtained as the Spalteholtz technique involves decalcification which makes the arteries stand out more clearly

RESULTS

In this investigation previous observations that the *odontoid process* receives its arterial supply via a system of longitudinal (ascending) and horizontal arteries could be confirmed The paired anterior and posterior ascending arteries arose from the vertebral artery The *paired horizontal* arteries apparently came from the internal carotid artery In this investigation difficulties arose in exactly verifying the origin of the horizontal arteries as the contrast medium in most specimens had disappeared during the excision but the contrast medium covered the wall of the internal carotid artery in many instances and there was a direct connection between the wall and the horizontal arteries

The anterior atlanto occipital membrane runs from the anterior lamina of the atlas to the base of the skull (Figure 2)

Main arteries in the odontoid region (Figure 3)

Adjacent to the odontoid process there are two main arteries, the internal carotid artery and the vertebral artery The internal carotid artery runs anterolaterally in a cephalad direction and enters the skull through the canalis caroticus The vertebral artery passes through the foramina transversaria of the cervical vertebrae and curves over the posterior lamina of the atlas It then continues into the skull through the foramen magnum

Close to the internal carotid artery there is the ascending pharyngeal artery, a branch of the external carotid artery

Arteries to the odontoid process

Review of the literature Only a few publications have been presented on the vascular supply of the odontoid process and there is a lack of uniformity in the descriptions Schatzker et al (1971 1975) described two main vascular sources One was derived from so called central arteries which entered the odontoid at its base and then ran in a cephalad direction inside its body The other source was described in a schematic drawing showing arteries which from the massa lateralis of the atlas reached the odontoid via the accessory ligaments Moreover it was suggested that vascular connections existed at the insertions of the alar and apical ligaments In the illustrations it is not conclusively demonstrated that these arteries actually penetrate into the odontoid process Arteries were demonstrated within the odontoid process but it was impossible to show with certainty what areas of the dens were supplied by these vessels (through the apical and alar ligaments) or whether any anastomoses existed between the vessels which entered the dens through the apical and alar ligaments and the central and peripheral arteries (Schatzker et al 1971)

Schiff & Parke (1973) demonstrated a regular vascular pattern *around* the odontoid Three main groups of vessels were described

1) anterior ascending arteries
2) posterior ascending arteries and
3) cleft perforators (horizontal arteries)

The latter arose from the internal carotid artery and anastomosed with the anterior ascending arteries at the odontoid base The anterior and posterior ascending arteries which appeared in pairs arose from the vertebral artery These arteries assembled in a vascular arcade on the top of the odontoid The anterior ascending arteries gave branches to the anterior aspect of the vertebral body of the axis to the base of the odontoid process and to its anterolateral surface The posterior ascending arteries gave branches to the posterior aspect of the vertebral body of the axis Further, Schiff & Parke (1973) described small holes on the surface of the odontoid and concluded that these were places of entrance for the arteries No arteries were demonstrated within the odontoid process

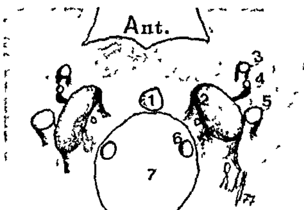


Figure 3 Main vessels just below the skull base in relation to the odontoid process and occipital condyles Seen from below and posteriorly

1 *Odontoid process*
2 *Occipital condyle*
3 *Internal carotid artery*
4 *Ascending pharyngeal artery*
5 *Internal jugular vein*
6 *Vertebral artery*
7 *Foramen magnum*

MATERIAL AND METHODS

The material for this investigation consisted of *six human cadaver cervical columns* The individuals had died from causes not related to disease in the vascular system Their ages were 62 65 67 67 70 76 years respectively There were *two women and four men* All specimens were injected *in situ* with a contrast medium intra arterially On excision the specimen contained the cervical column with the base of the skull

The contrast medium consisted of a mixture of two parts 10 per cent formaldehyde and one part Micropaque The injections were given according to *Mulfinger & Trueta (1970)* 36 48 hours following death Mulfinger & Trueta (1970) demonstrated that by injecting vessels 36 48 hours post mortem -during which time the *capillary bed is destroyed by autolysis*—the contrast medium does not pass over to the veins

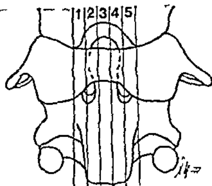


Figure 4 a Longitudinal in sagittal plane

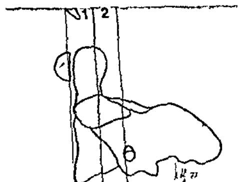


Figure 4 b Longitudinal in frontal plane

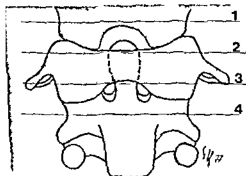


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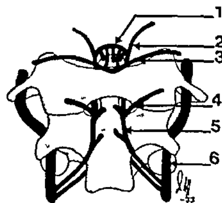


Figure 5 Anterior aspect of the atlas and axis with arteries

1 *Apical arcade*
2 *Posterior horizontal artery*
3 *Superior anterior horizontal artery*
4 *Inferior anterior horizontal artery*
5 *Anterior ascending artery*
6 *Vertebral artery*

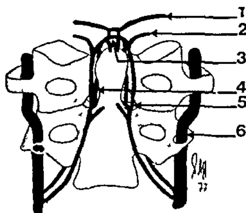


Figure 6 Posterior aspect of the body of the axis odontoid process and massa lateralis of the atlas with the lamina of the atlas and axis cut

1 *Superior anterior horizontal artery*
2 *Posterior horizontal artery*
3 *Apical arcade*
4 *Anterior ascending artery*
5 *Posterior ascending artery*
6 *Vertebral artery*

Paired anterior ascending arteries
(Figures 5, 7 and 10)

These arteries branched off from the vertebral arteries immediately caudal to the axis Their course was cephaled on the anterolateral surface of the axis and near the base of the odontoid process each artery gave a branch which penetrated into the odontoid within which it then ran posteriorly and cephalad branching eventually into a network of fine arteries

The anterior ascending arteries continued their course on the anterolateral surface of the odontoid and over the apex of this they joined and, anastomosing also with branches from the posterior ascending arteries, they here formed the apical arcade

Paired posterior ascending arteries
(Figures 6, 7, 10 and 11)

The posterior ascending arteries branched off from the vertebral arteries at the same level as the anterior ascending arteries The posterior ascending artery ran cephalad on the posterolateral surface of the axis giving off branches to the body of this vertebra At the base of



Figure 7 Sagittal section through the upper cervical spine Radiograph of Spalteholtz preparation (cf Figure 4 a no 1 slice thickness 5 mm)

1 *Anastomosing artery between the superior anterior horizontal artery and the apical arcade*
2 *Part of the apical arcade*
3 *Posterior ascending artery*
4 *Part of the anterior ascending artery*



the p cture Seen from above and posteriorly

1 Posterior ascend ng artery
2 Branch from the posterior ascend ng artery which runs along the accessory ligament to the lateral aspect of the odontoid base where it
3 penetrates the bone and divides into an arterial network
4 Anterior ascending artery
5 An anterior artery penetrating into the odontoid process
6 Inferior anterior hori ontal artery

the odontoid process one branch turned off and slightly caudad to the transverse ligament it penetrated into the odontoid within which it then divided into a num ber of small branches Each of the paired posterior ascending arteries also gave off one branch which ran along the accessory ligament to the insertions laterally on the base of the odontoid where it penetrated into the bone The posterior ascending arteries continuing in a cephalad direc tion passed posterior to the alar liga ments on top of which they turned medially and anteriorly Joining the apical arcade they contributed to the formation of a vascular network round the tip of the odontoid and the alar liga ments There were thus anastomoses con necting all the four ascending arteries From this apical network branches were given off which descended into the odontoid within which further divisions occurred

In this investigation it proved impossible to demonstrate any vessels penetrating into the odontoid process within the circumscribed region of the insertion of the alar ligaments

Anterior horizontal arteries
(Figures 5 6 7 and 8)

These vessels, two on each side, one inferior and one superior, ran horizontally on the anterior surface of the atlas The inferior horizontal arteries anastomosed under the anterior lamina of the atlas with the ipsilateral anterior ascending artery The superior horizontal arteries anastomosed with each other in the midline, and moreover, gave off branches which penetrated the atlanto-occipital membrane and established contact with the apical vascular network

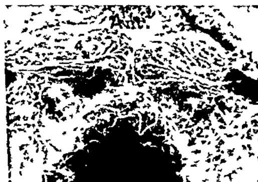


Figure 9 Hori ontal section through the uppermost part of the cervical spine Rad ograph of Spalteholt preparation (cf Figure 4 c no 1 slice thickness 12 mm) Seen from above and posteriorly

1 Internal carotid artery
2 Posterior hori ontal artery (branch from the ascending pharyngeal artery)
3 Apical arcade
4
5
6 Capsular artery

Posterior horizontal arteries
(Figures 5, 6 and 9)

These arteries branching off from the ascending pharyngeal artery and running horizontally through the canalis hypoglossi of the occipital condyle at the level of the foramen magnum turned anteriorly and downwards and reached the apex of the odontoid process where they linked up with the apical vascular network

Intraosseous anastomoses
(Figures 8, 10 and 11)

The arteries entering the odontoid process at its base anastomosed inside the odontoid with those arteries entering the odontoid at its apex The interior of the odontoid process was the site of a rich anastomotic network of arteries



Figure 10 Sagittal section through the odontoid process Radiograph of Spalteholtz preparation (cf Figure 4 a no 3 slice thickness 5 mm)

1. *Transverse section through the apical arcade*
2. *Apical artery penetrating into the odontoid process*
3. *An anterior artery penetrating the base of the odontoid process Note the rich anastomosing network within the odontoid process and the anastomosing arteries between the apical and basal arteries*



Figure 11 Frontal longitudinal section Radiograph of Spalteholtz preparation (cf Figure 4 b no 1, slice thickness 10 mm)

1. *An anterior artery penetrating the base of the odontoid process dividing into a fine anastomosing network*
2. *Anastomosing artery between the basal and apical arteries*

3 and 4 Arteries penetrating the apex

There were arteries running along with the accessory and apical ligaments penetrating into the odontoid process No arteries could be seen to run into the bone from the interior of these ligaments Vessels from the apical arcade ran along the alar ligament without penetrating the odontoid bone

DISCUSSION

From this investigation it has thus become evident that the odontoid process is in the centre of a rich network of arteries Arteries were seen to penetrate into the odontoid around its base and at its apex Vascular connections were demonstrated between ligament and bone except in the case of the alar ligaments No arteries could be observed to traverse into the odontoid at the insertions of these ligaments The failure to demon

strate this may simply be a matter of technique and be related to the contrast medium used However, it should be mentioned that a good filling of arteries was present in the arteries around the ligament as well as in the intraosseous area bordering the zone where the ligament inserts In the translucent specimens it was impossible to detect any arteries and random histologic sections have not revealed any signs of vascular supply in this special region of ligamentous attachment On the other hand vascular connections were observed between the inside of the odontoid process and the vessels running along the apical and accessory ligaments In studies of the vascular supply between ligaments and bone it has previously been demonstrated (Moseley & Goldie 1963 Peterson et al 1974 Bjorkstrom 1976 personal communication) that vascular connections exist and the present observations coincide with those made in previous investigations

The arterial arcade above the odontoid process has previously been described to have its origin in the anterior and posterior ascending arteries In this investigation however it was demonstrated that the arcade receives arterial branches from other sources as well such as for example the ascending pharyngeal artery a branch of the external carotid artery and those arteries apparently branches of the internal carotid artery which penetrate the membrana atlanto occipitalis Thus the intraosseous arterial supply of the odontoid process is not entirely dependent on the anterior and posterior ascending arteries This investigation has made clear that in cases of high odontoid fractures with or without interfragmentary dislocation the arterial supply need not necessarily be damaged to an extent that the superior part of the odontoid process looses its blood supply as there are sources other than the anterior and posterior ascending arteries This problem is the subject of further study

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Acta orthop scand 48, 630-634, 1977

RESULTS OF OPERATIVE TREATMENT OF LUMBAR DISC HERNIATION

A Survey of 886 Patients

P SALENIUS & L E LAURENT

The Orthopaedic Hospital of the Invalid Foundation, Helsinki, Finland

Over a period of 6 years (1960-65), 886 patients were operated on for herniated lumbar disc In 1971, 695 of these patients (78 5 per cent) answered a questionnaire The material was analysed with the aid of a computer Persons in the age groups 30-39 (38 per cent) and 40-49 (34 per cent) were most prone to develop sciatica At operation the distribution of positive findings was found to be 5 7 per cent at level L3-4 58 3 per cent at L4-5 and 36 per cent at L5-S1 Myelography with a water soluble medium was performed preoperatively in all cases and gave a correct diagnosis of level in 90 2 per cent The late results were good in 56 per cent of patients and 63 per cent returned to their former occupation

Key words lumbar disc herniation operative results, sciatica, social factors

Accepted 10 xi 77

The initial enthusiasm regarding operation for lumbar disc herniation has in recent years been modified by reports of disappointing late results (Falconer et al 1948, Burns & Young 1951, Spurling & Grantham 1949, Kallio & Torma 1965, Karaharju et al 1974) Also there have been reports of good results after conservative treatment of sciatica (Hakelius 1970)

The purpose of this paper is to report an investigation, based on a questionnaire, of the primary and late results of patients operated on for disc herniation, during the period 1960-1965, at the Orthopaedic Hospital of the Invalid Foundation

MATERIAL

From 1960 to 1965 a total of 886 patients were operated on for sciatica In 1971 a questionnaire was sent to them Answers came from 695 patients (78 5 per cent) The data obtained were analysed in a computer

The operations were performed under general anaesthesia with the patients in a prone position Exploration was carried out unilaterally with partial removal of laminar bone above and sometimes below the selected level Hemilaminectomy and facetectomy were seldom necessary All degenerated disc tissue was removed from the intervertebral space A posterior fusion was performed simultaneously in 25 patients (2 9 per cent) The sex and age of the patients is shown in Table 1 Sixty six per cent were males and 34 per cent females Thirty eight per cent of the patients belonged to the age group 30-39 years and 34 per cent to the age group 40-49

Table 1 Sex distribution and number of patients in the various age groups

Age	Males	Females	All	%
10–19	3	1	4	0 4
20–29	50	24	74	8 1
30–39	212	121	333	38
40–49	194	111	305	34
50	124	46	170	20 5
	583(66%)	303(34%)	886	100

Table 2 Nature of work before operation

Heavy manual	289 (33 %)
Manual	243 (27 %)
Light	354 (40 %)
Total	886 (100 %)

Forty per cent were engaged in light work, 27 per cent in manual work and 33 per cent in heavy manual work (Table 2)

The preoperative duration of sciatica was 1–3 months in 42 per cent 4–12 months in 44 per cent and more than 1 year in 14 per cent of the patients Sixty eight per cent had a history of back pain of more than 1 years duration The radiating pain was left sided in 51 per cent right sided in 40 per cent and bilateral in 9 per cent of cases The Lasègue sign was positive in 81 per cent of the patients There were eight patients (0 9 per cent) with a cauda equina syndrome A total of 122 (14 per cent) had previously been operated on and had a second exploration because of recurrence of sciatica In 35 patients two levels were explored and in 12 patients three levels

A preoperative myelography with water soluble contrast medium (Contrast U) was performed in all cases (Table 3) The myelography was positive in 836 cases Of these the operative finding was also positive in 693 cases (83 per cent) and negative in 51 cases (6 per cent) In 92 cases (11 per cent) the operative finding was marked as "adhesion" Out of the 50 cases with negative myelography findings the operative finding was also negative in 14 cases (28 per cent) Thus the myelographic and operative findings agreed with each other, if the cases recorded as "adhesion" are considered as positive findings, in 799 cases or 90 per cent Of the 86 patients with a weakness of the extensor hallucis longus muscle the disc herniation was located at the level L4–5 in 68 cases, at L5–S1 in 12 and at L3–4 in 6 cases Out of 200 patients with a weakened ankle jerk the herniation was located at the level L5–S1 in 143 patients and at L4–5 in 66 patients The rate of negative exploration was 7 0 per cent (65/886) In 92 cases (11 per cent) the positive finding consisted of adhesions to the nerve root

The distribution of positive operative findings was as follows L3–4 level 5 7 per cent, L4–5 58 3 per cent and L5–S1 36 per cent

Patients were allowed to walk about the day after operation Physiotherapy was commenced if the patient's back was stiff 4–6 weeks after operation

Complications

Two patients died of embolism of the lung 1 week after operation The mortality rate was 0 2 per cent Superficial wound infection occurred in 17 patients (1 9 per cent) Postoperative discitis occurred in four patients (0 4 per cent) These healed with antibiotic treatment in 3–4 months

RESULTS

Primary results

Of the 656 patients who answered this question 320 (49 per cent) returned to work within 4 months Ninety-seven patients (15 per cent) were unfit to work for more than 6 months If the period of inability to work had lasted for a long

Table 3 Myelographic and operative findings

Myelographic finding	Total	Operative finding: Positive	Negative	Adhesion
Positive	836 (100 %)	693 (83 %)	51 (6 %)	92 (11 %)
Negative	50 (100 %)	31 (62 %)	14 (28 %)	5 (10 %)
Total	886 (100 %)	724 (82 %)	65 (7 %)	97 (11 %)

Table 4. Primary results: comparison of periods of inability to work before and after operation

Period of incapacity before operation (months)	Total	Period of incapacity after operation (months)			
		Less than 2	2-4	4-6	Over 6
0-3	282 (100 %)	155 (55 %)	87 (31 %)	23 (8 %)	17 (6 %)
3-6	150 (100 %)	73 (49 %)	41 (26 %)	10 (7 %)	27 (18 %)
6-12	135 (100 %)	64 (48 %)	37 (27 %)	11 (8 %)	23 (17 %)
Over 1 year	89 (100 %)	28 (31 %)	18 (20 %)	12 (14 %)	31 (35 %)
Total	656 (100 %)	320 (49 %)	183 (28 %)	56 (9 %)	97 (15 %)

Table 5. Primary results: Period of inability to work after operation divided according to nature of work

Work before operation	Total	Returned to work in			
		Less than 2 months	2-4 months	4-6 months	Over 6 months
Heavy manual	258 (100 %)	83 (32 %)	82 (32 %)	32 (12 %)	61 (24 %)
Manual	268 (100 %)	137 (51 %)	78 (29 %)	21 (8 %)	32 (12 %)
Light	130 (100 %)	100 (77 %)	23 (18 %)	3 (2 %)	4 (3 %)
Total	656 (100 %)	320 (49 %)	183 (28 %)	56 (9 %)	97 (15 %)

Table 6. Late results in terms of the patients' condition at follow-up

Age	Total	Condition of patient at follow-up		
		Cured	Unchanged	Worse
Under 40 years	306 (100 %)	189 (62 %)	90 (29 %)	27 (9 %)
Over 40 years	314 (100 %)	155 (49 %)	134 (43 %)	25 (8 %)
Total	620 (100 %)	344 (56 %)	224 (36 %)	52 (8 %)

time before operation, convalescence also took a long time (Table 4). The nature of the work also influenced the period of convalescence (Table 5).

Good or satisfactory results were obtained in 70 per cent of cases, fair results in 14 per cent and poor in 16 per cent.

Late results

Some patients did not answer all the questions and therefore the patient groups differ in number of cases.

The follow-up time was 6-11 years. At follow-up 344 out of 620 patients (56 per cent) stated that they had little or no pain (Table 6). In 224 patients (36 per cent) the pain was the same as before operation and in 52 (8 per cent) it had become worse. As regards fitness for work at follow-up, 284 out of 652 patients (44 per cent) stated that they were fully capable of working and 274 patients (42 per cent) were in their opinion only partially capable. Ninety-four patients

Table 7 Late results Nature of work at follow-up

Work before operation	Total	Work at follow up				
		Previous	Lighter	Heavier	Not working	On pension
Heavy manual	236 (100 %)	128 (55 %)	33 (14 %)	–	15 (6 %)	60 (25 %)
Manual	249 (100 %)	158 (64 %)	18 (7 %)	6 (2 %)	24 (10 %)	43 (17 %)
Light	124 (100 %)	108 (87 %)		3 (2 %)	6 (5 %)	7 (6 %)
Total	636 (100 %)	394 (66 %)	51 (8 %)	9 (2 %)	45 (7 %)	110 (17 %)

(14 per cent) stated that they were unfit for work

Out of 636 patients 394 (66 per cent) had returned to their former employment (Table 7) 51 patients (8 per cent) had changed to a lighter job and 9 patients (2 per cent) to a heavier job 155 patients (24 per cent) stated that they were unfit for work 110 of them (17 per cent) were receiving a pension At the time of the follow up 47 patients were over the age of 63

The results of 43 fusion operations 25 in connection with the disc prolapse removal and 18 at a later stage were satisfactory in half the cases and poor in the other half

DISCUSSION

Low back pain and sciatica are among the commonest causes of inability to work Conservative treatment should always be tried first and patients should be carefully selected for operation

According to this investigation the following criteria indicated a good result after operative treatment of a prolapsed disc

Medical factors No previous back operations Painful preoperative signs of a herniated disc A short period of sciatica before operation

Social factors Patient not in heavy work or able to change to lighter work if necessary Preoperative period of unemployment as short as possible Education more than elementary school The younger the patient the better his prognosis

In this series 33 per cent were doing heavy manual work and 40 per cent non manual work This means that a herniated disc can occur in any category of work It is clear however that after operation those doing heavy manual work more often have back pain and recurring sciatica In younger individuals training for a new lighter occupation is often advisable

In this series the distribution as regards age and sex of the patients was approximately the same as in other published studies collected by *Spangfort* (1972)

Seventy two per cent of the patients belonged to the age group 30–49 The distribution of the level of a positive finding during operation was as follows 5 7 per cent L 3–4 58 3 per cent L 4–5 and 36 per cent L5 S1 The rate of herniation at the level L4 5 was somewhat higher in this series than in other publications

It is difficult to decide the level of herniation on the basis of clinical findings Myelography using a water soluble contrast medium (Contrast U) gave a correct diagnosis of level in 90 2 per cent of patients A negative myelogram sometimes is taken as a contraindication to operation The clinical signs are decisive however a herniation in a large L5 S1 space for instance will not always be

visualized during myelography The new myelography technique with Dimer-X makes exposure in a standing position possible, which makes the investigation even more reliable In our hospital myelography always precedes an operation In this series there was a tendency for disc herniation to be located at a higher level with increasing age, which agrees with the observations of Spangfort (1972)

Results indicate that an operation should be considered if a period of 4–6 weeks of conservative treatment gives no relief from pain If the patient has severe pain, or there are clear signs of root compression and the myelogram is positive, an operation is indicated even sooner Under these circumstances if the operative finding is positive, the result of operation is generally good It may seem, however, that the condition of the patient's back 5–11 years after operation is not as satisfactory as the primary results indicated If the patient is near retirement, prolonged conservative treatment is advisable The results of reoperation for herniated disc on the same side and level as the primary operation seem not to be very satisfactory A simultaneous fusion may be indicated by the second exploration The results of this procedure, however, gave a satisfactory result in only about half the patients The results after a third intervention are often poor

The late results in this series are comparable with earlier published results 56 per cent of the patients stated that they had little or no pain, and 63 per cent had returned to their former employment

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DOUBLE BLIND EVALUATION OF EXTRADURAL METHYL PREDNISOLONE FOR HERNIATED LUMBAR DISCS

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A double blind study was carried out in 51 patients suffering from lumbar root compression syndrome of 12 days to 36 weeks duration All patients had signs symptoms and radiological abnormalities related to a herniated lumbar disc Each patient received an extradural injection of either 2 ml (80 mg) methyl prednisolone or 2 ml normal saline solution Neurological examination and interview of the patients with the aid of a questionnaire before and after extradural injection failed to demonstrate any statistically significant difference in outcome between the two groups At follow up 14 ± 6 months after extradural injection 58 3 per cent of the patients in the control group and 51 9 per cent of the patients in the treatment group had undergone surgical treatment with laminectomy Our results indicate that a single extradural injection of methyl prednisolone (80 mg) is no more effective than a placebo injection in relieving chronic symptoms due to myelographically demonstrable lumbar disc herniation

Key words sciatica intervertebral disc displacement, extradural injections methyl prednisolone

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For more than 20 years water-soluble corticosteroid drugs have been used in the treatment of sciatica Various administrative techniques have been employed Extradural injection at the affected lumbar level (Barry & Hume Kendall 1962), or at the sacro-coccygeal level via the sacral hiatus (Lindblom & Salenius 1964) and via dorsal sacral foramina (Renier 1959), local intrathecal injection (Sehgal & Gardner 1960) and systemic application by the intramuscular route (Green 1975), have all been advocated Corticosteroid infiltration of the extradural space at the affected spinal level now appears to be the most popular technique If effective it constitutes a major advance in the non-operative management of the lumbar root compression syndrome It is rapid, can be performed on an out-patient basis and appears to be safe (Jurmand 1973), although warnings have been given about the dangers of intraspinal injections without proper diagnosis (Shealy 1966) Many papers appear to prove the effectiveness of extradural steroid injections but there is a scarcity of controlled studies which take account of the variable and episodic nature of the pain characterizing the natural history of the lumbar root compression syndrome

Table 1. Comparability of groups before injection. Clinical data of 51 patients with herniated lumbar disc

	Placebo	Methyl prednisolone
Total treated	24	27
Average age in years (range)	46.5 (27–67)	43.8 (20–59)
Sex		
Males	13	13
Females	11	14
Duration of main complaint (present attack)		
Average	10.8 weeks	11.5 weeks
Range	17 days–36 weeks	12 days–36 weeks
Vertebral levels of disc herniation		
L_3–L_4	2	
L_4–L_5	11	15
L_5–S_1	11	12
Neurological deficit	24	27
Sciatic scoliosis and/or lumbar deviation	15	16
Positive Lasegue's sign	20	22
Abnormal ankle jerk	15	12
Non-progressive lower extremity weakness	9	8
Radicular sensory deficit	10	10
Pain	24	27
Low back pain	8	9
Radiating pain	24	27
Impulse pain	14	20
Pain interfering with sleep	13	13
Necessity for analgesics	19	20
Records obtained from physiotherapist	14	20

(Pearce & Moll 1967). The aim of the present study therefore is to evaluate objectively methyl prednisolone, 80 mg, applied extradurally at the fourth lumbar, fifth lumbar or first sacral nerve root level in the treatment of the lumbar root compression syndrome.

MATERIAL

The patients included in this study were selected from a consecutive series of more than 200 patients admitted to the Department of Neurology, Ullevål Hospital between May 1974 and April 1975, for treatment of unilateral sciatica.

The criteria for admission to this trial were the presence of (1) radiating pain in the distribution of the sciatic or femoral nerves, (2) a neurological deficit that correlated with a compression of the fourth or fifth lumbar or first sacral nerve root and (3) myelographic findings at the appropriate level and side. Lumbar myelography was performed with metrizamide (Amipaque®). Radiologically diagnostic features were indentation of the dural sac and/or increased width of the root and shortening of the root sleeve.

Grounds for exclusion were acute severe motor paresis, evidence of compression of the cauda equina, intolerable pain, previous surgery to the lumbar spine, coincident medical conditions known to be contraindications to corticosteroid therapy and any doubt about the myelographic findings.

51 patients satisfied the criteria and consented to participate in the trial.

METHODS

The selected patients were randomly divided into two comparable groups (Table 1) by one of the authors (B.J.). The control group received a lumbar extradural injection of 2 ml of normal

saline and the treated group received an injection of 80 mg (2 ml) methyl prednisolone acetate (Depo Medrol®) All injections were performed by BJ using the direct approach through the interspinous ligament at the level of the disc lesion as described by Barry & Hume Kendall (1962) The patients were placed on the affected side with hips and spine fully flexed The extradural space was identified by the "loss of resistance test" of Dogliotti (1933), and after the injection the patients were left on the same side for a few minutes to allow accumulation of the steroid at the required level and side

All patients were restricted to bed for the first 7 days of hospitalization but from the eighth day were allowed to walk about freely Physiotherapy mainly consisting of instruction and isometric training of the appropriate muscle groups was identical for all The duration of stay at the department of neurology was 14 ± 4 days Those patients who did not improve sufficiently were then transferred to the physiotherapy department or to the neurosurgery department if a complete evaluation indicated the need for laminectomy

All patients were examined by the same neurologist (W S) 12 ± 10 hours before and 48 ± 24 hours after the injection Neither patient nor examiner knew to which group the patient belonged The following variable factors were recorded

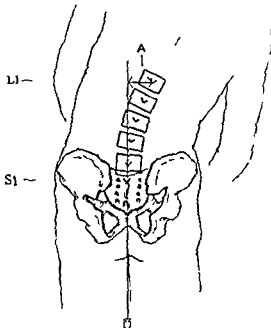


Figure 1 Measurement of mobility in the frontal plane of the lumbar spine The patient performs a maximal lateral flexion to both sides The distance A between the plumb line through S_1 and the spinous process L_1 is measured in cm (From Weber 1973)

1) *Mobility and deformity of the lumbar spine*

The spinal process of L_1 and S_1 were marked on the skin The patient stood with his back to the examiner with equal weight on both feet and a plumb line was suspended in such a manner that it covered the spinal process of S_1 at all times during the examination Any sciatic scoliosis or lumbar deviation was recorded and if it disappeared after [illegible]

spinal process of L_1 was recorded (Figure 1) Thus a reproducible expression of the mobility in the frontal plane was obtained The examiner constantly checked with his hands that the hip area did not move The mobility in the sagittal plane was recorded as the difference in the distance between S_1 and L_1 in the neutral position and maximal forward and backward flexion respectively An increase in mobility of 2 cm or more in either plane after injection was categorized as improvement

2) *Lasègue's test*

This was performed with the patient lying on his back keeping the knee straight the leg was slowly raised until the patient experienced radiating pain in the distribution of the sciatic nerve A "positive Lasègue sign" was recorded when the test provoked radiating pain before 50° elevation was accomplished The recording of the angle of elevation was made with a goniometer If after injection the angle had improved by 20° or more this was recorded as increased sciatic nerve stretch tolerance

3) *Neurological deficit*

a) Ankle [illegible]
the [illegible]
knee [illegible]
cont [illegible] and
seventh strikes against the Achilles tendon Deflection of the movement of the foot on the unaffected leg was used as a control

b) *Motor function* This was examined in all patients by the conventional manual technique The strength of the muscles with the following functions was measured during maximum isometric contraction dorsal extension of the big toe the four lateral toes and the entire foot eversion of the foot abduction and extension of the leg and flexion of the foot and the knee

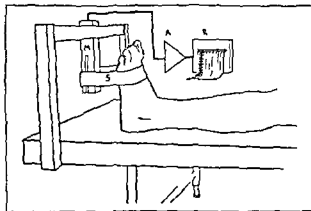


Figure 2. Measurement of strength in the muscle groups which cause dorsal flexion of the foot (from Weber 1975)

The maximum muscle strength here is defined as the maximum force which the muscle can develop and maintain for a brief period of time (1–2 seconds). In 17 patients with a detectable paresis, the isometric strength in the affected muscle groups was recorded mechanically as shown in Figure 2. The patient lay on a bench. With the aid of a non-stretchable strap, the foot was fixed to a measurement beam with built-in strain gauges. The electrical signals were transferred to a direct recorder which showed the deflections on squared paper. The mean value of two readings was recorded but if the difference between these exceeded 5 per cent of the deflection a third measurement was made. In this way one always obtained two recordings which satisfied the requirements. Corresponding muscle groups were examined alternately in the affected and the unaffected leg with exactly the same starting position and necessary support. The difference in the measured strength in the two legs provided an expression of the degree of the paresis and corresponded well with the clinical evaluation.

c) *Sensory function.* The patients reaction to pin pricking was examined in both legs. In 20 instances a radicular sensory deficit was detected and the localization and extent of this were recorded on a sensibility scheme.

4) *Pain*

For the patient with sciatica, pain is the dominating and most disabling symptom. With the aid of a questionnaire the subjective pain was recorded before and after injection. The following types of pain were defined and assessed.

a) low back pain, which was a prominent feature in only 17 of the patients. If it disappeared after injection, this was recorded as improvement.

b) radiating pain in the distribution of either the sciatic or femoral nerve was present in all patients. If it disappeared or did not extend as far after injection, this was recorded as improvement.

c) impulse pain, i.e., provocation or worsening of radiating pain by coughing or sneezing is thought to be a sign of spinal nerve root irritation and was present in 34 patients of our series. If this sign disappeared after injection this was recorded as improvement.

d) pain interfering with sleep, wakening the patient at night or completely inhibiting normal sleep was reported in 26 cases. Improvement was recorded if after injection the subjects no longer awakened because of pain.

5) *Analgesic consumption*

The patients were given an analgesic tablet on *request only*. Two different compounds were used, but each patient only received one of these. If after injection the patient no longer requested any analgesic, this was recorded as an improvement.

6) *Statement by the physiotherapist*

The patient's physiotherapist recorded his impression of the condition of the patient on the basis of clinical judgement of the patient's ability to perform physical activities before and after injection. The physiotherapist did not know which type of injection had been given. Records were only available for 35 of the patients.

7) *The patient's own assessment*

At the second examination the patient was asked if he subjectively felt an improvement had experienced no change or had deteriorated after the extradural injection.

RESULTS

Early results

Table 2 presents the results, indicating a general improvement in both the treated and the control group. The difference in results between the two groups is statistically not significant.

Follow-up study

All patients included in this study were reviewed in December 1975. The follow-up period ranged from 8 months for

Table 2 Early results

	Placebo (%) *	Methyl prednisolone (%) *	P **
Improvement of sciatic scoliosis and/or lumbar deviation	33 3	12 5	0 34
Increased mobility in lumbar spine			
Sagittal plane	8 3	25 9	0 20
Frontal plane	50 0	44 4	0 92
Increased sciatic nerve stretch tolerance	25 0	36 4	0 65
Improvement of abnormal ankle jerk	0 0	0 0	
Improvement of lower extremity weakness	0 0	25 0	0 40
Improvement of radicular sensory deficit	0 0	0 0	
Relief of low back pain	25 0	33 3	0 83
Relief of radiating pain	12 5	25 9	0 37
Relief of impulse pain	7 1	25 0	0.38
Relief of pain interfering with sleep	23 1	53 8	0 24
Discontinuance of analgesic consumption	15 8	40 0	0 19
Improvement stated by physiotherapist	42 8	70 0	0.22
Improvement felt subjectively by the patient	41 7	66 7	0 13

* Refers to the number of affected patients who improved, not the degree of improvement Compare with basic data in Table 1

** Differences between groups have been tested by ordinary chi square statistical methods with one degree of freedom and with Yates correction, regarding P values less than 0 05 as significant

those admitted in April 1975 to nearly 20 months for those admitted in May 1974 The patient records were reviewed to ascertain whether laminectomy had been necessary since injection Where this information could not be obtained from the record, the patient was contacted by letter or telephone Review of the operation records from the department of neurosurgery showed that in all the cases operated upon, i e, 14 patients in each group, a disc prolapse was found at the level and side indicated by myelography

Complications

Apart from a few patients who felt increased pain of sciatic distribution shortly after the extradural injection, there were no complications or side effects attributable to the injection

DISCUSSION

In our study there was no statistically significant difference in the outcome between the treated and the control group It follows that a single dose of methyl prednisolone, 80 mg injected extradurally was no more effective than the placebo in relieving chronic symptoms due to lumbar disc herniation demonstrable by myelography

Our conclusion is derived from a small number of patients and contradicts the wider based experience of many different researchers However, of the previous trials only Dilke et al (1973) have reported a carefully controlled double blind study of extradural steroid medication In a series of 100 consecutive patients with a clinical diagnosis of lumbar root compression by a herniated lumbar disc they observed significant alleviation of the symptoms after injection of methyl prednisolone, 80 mg The apparent disparity in results between their study and

our own may be related to a difference in selection of material since Dilke et al *did* not consider myelography findings as a criterion, whereas all the patients in our study had a demonstrable disc herniation Harley (1967) demonstrated that most of the patients who benefit from extradural steroid infiltration have no myelographic abnormality, and Colonna & Friedenberg (1949) showed that the prognosis of non-operative treatment is poorer when the extruded mass of the disc reaches a stage where it can be visualized by myelography

Our results reflect the findings at 48 ± 24 hours after treatment Burn & Langdon (1974) found a temporary relief of symptoms in 37 per cent of their patients treated with extradural steroid injection and manipulation under anaesthesia The period of relief of symptoms varied from only a few days to several months It may be therefore that further follow-up of our own patients would have yielded even poorer results

Our placebo injection appeared to be strikingly effective It is unreasonable, however, to suspect any therapeutic action from extradural injection of 2 ml normal saline Certainly Evans (1930) found that extradural injection of 30 ml of normal saline relieves sciatic pain, but this is fifteen times the amount used in our study More likely the general improvement of our patients in both groups is at least in part due to the strict bed rest which was instituted directly after admission

In this study myelography was performed with metrizamide (Amipaque®), a water-soluble contrast which has been shown to have markedly reduced irritative effects compared with other water-soluble contrast media (Skalpe et al 1973) The use of metrizamide is therefore unlikely to have had any direct effect in itself on the patients' symptoms or signs

In assessing the significance of our results, it should also be taken into account that only a single dose of methyl prednisolone, 80 mg, was given and only patients with long-standing symptoms of lumbar root compression, nearly 3 months' duration on average, were included in our study According to Solheim (1960) and Jurmand (1973) acute cases of sciatica respond better to extradural steroid infiltration than do the subacute and chronic cases Dilke et al (1973) claim that a second injection of methyl prednisolone given a few days after the first may be successful when there has been incomplete or even no response to the first, whereas a third injection is rarely helpful Burn & Langdon (1974) showed that the duration of action of methyl prednisolone when injected into the extradural space was about 2 weeks Hence another injection after a few days means accumulation of the active substance We found it difficult, however, to investigate with double blind methods the possible effect of repeated injections Further investigations are required to assess objectively the value of higher steroid dosage and the effectiveness of extradural steroid medication in acute cases of sciatica with and without myelography findings

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Our placebo injection appeared to be strikingly effective It is unreasonable, however, to suspect any therapeutic action from extradural injection of 2 ml normal saline Certainly Evans (1930) found that extradural injection of 30 ml of normal saline relieves sciatic pain, but this is fifteen times the amount used in our study More likely the general improvement of our patients in both groups is at least in part due to the strict bed rest which was instituted directly after admission

In this study myelography was performed with metrizamide (Amipaque®), a water-soluble contrast which has been shown to have markedly reduced irritative effects compared with other water-soluble contrast media (Skalpe et al 1973) The use of metrizamide is therefore unlikely to have had any direct effect in itself on the patients' symptoms or signs

In assessing the significance of our results, it should also be taken into account that only a single dose of methyl prednisolone, 80 mg, was given and only patients with long-standing symptoms of lumbar root compression, nearly [illegible] months' duration on average, were included in our study According to Solheim (1960) and Jurmand (1973) acute cases of sciatica respond better to extradural steroid infiltration than do the subacute and chronic cases Dilke et al (1973) claim that a second injection of methyl prednisolone given a few days after the first may be successful when there has been incomplete or even no response to the first, whereas a third injection is rarely helpful Burn & Langdon (1974) showed that the duration of action of methyl prednisolone when injected into the extradural space was about 2 weeks Hence another injection after a few days means accumulation of the active substance We found it difficult, however, to investigate with double blind methods the possible effect of repeated injections Further investigations are required to assess objectively the value of higher steroid dosage and the effectiveness of extradural steroid medication in acute cases of sciatica with and without myelography findings

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Table 1 Incidence of neonatal hip instability

Author and date of study	Comments	Incidence (Per mille)
Sweden		
Palmén 1961	Own material	5.7
Palmén 1961	Obstetric clinics (1953–1960)	2.2
Palmen 1961	Obstetric clinics (1953–1960) with provoked instability test	5–6
Palmén 1961	Clinics in Gothenburg and Malmo	2.0
Emnéus 1966	63/16 638	3.8
James & Hierton 1968	All cases admitted for orthopaedic consultation	20.0
Emneus & Undeland 1970		4.5
von Rosen 1970	1956	1.3
	1965	12.9
	Average	4.7
Hirsch & Scheller 1970	1961	13.0
	1962	12.9
Palmén & von Rosen 1975	For the whole country (1963)	5.6
Fredensborg 1975		9.3
Elsewhere		
Barlow 1962		14.9
Finlay et al 1967		5.0
Williamson 1972	192/29 000	6.6
Mackenzie 1972	1969 1970	21.8
Bjerkreim 1974		8.0
Artz et al 1975		13.3
Nielsen 1975		0.74

sented, especially of the pioneering work of Palmen and von Rosen The incidence of neonatal hip instability has been calculated Table 1 gives some of these figures as well as the incidence in some other countries

In the thesis presented by Fredensborg in Malmo (1975), it was stated that early diagnosis and treatment had been very successful during the period 1956 1972, only 0 07 per mille were diagnosed after the neonatal period (= first month of life) Other investigators have found, however that early diagnosis and treatment has not considerably reduced the number of so called "missed' cases (Williamson 1972 Mackenzie 1972, Bjerkreim 1974 Nielsen 1975) Even in Sweden when one compares the last few years with the mid sixties (Palmén & von Rosen 1975, Palmén 1977, personal communication), there is a tendency for more cases to be diagnosed during the age of 1 6 months

In Uppsala early diagnosis and treatment started in the late fifties It is now an established routine procedure, in principle the same as in other Swedish maternity wards with regular examinations by paediatric consultants Nevertheless there are a few "missed" cases every year, which are picked up later in the Paediatric Health Care Centres The following study has been undertaken with the purpose of elucidating and examining the effectiveness of our diagnostic and therapeutic routines

MATERIAL AND METHODS

The material consists of all children who have been referred in the neonatal period (= first month of life) from the maternity ward to the orthopaedic department in the University Hospital of Uppsala with signs of hip instability,

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NEONATAL HIP INSTABILITY

Incidence, Diagnosis and Treatment at the University Hospital, Uppsala, 1960–1964 and 1970–1974

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Neonatal hip instability, its incidence, diagnosis and treatment has been studied retrospectively for the periods 1960–1964 and 1970 1974 The respective populations for the two periods amounted to 13 065 and 16,274 children all born at the same hospital During the first period 191 children (14 per mille) were referred from the maternity ward to the orthopaedic department with suspected hip instability, 109 (8 3 per mille) children were considered by the orthopaedic consultant to have unstable hips During the second period the corresponding figures were 503 (31 per mille) referred to the orthopaedic department and 189 verified as unstable (11 6 per mille) During the first period 177 children were treated with Frejka pillows for about 3 months only 14 being left untreated In seven children the initial treatment was completed with a plaster cast The results were uniformly good During the second period 195 children were treated with a von Rosen splint for 6 weeks followed by Frejka pillows for another 6 weeks (seven completed treatment with plaster) In 143 cases Frejka pillows were the sole treatment and 161 had no treatment at all There was one primary plaster The treatment resulted in normal hips in all but one girl In the non treated group three subluxations were verified after the neonatal period There were seven 'missed' cases (diagnosed after the first month of life) in the first population (0 5 per mille) 15 in the second (0 9 per mille) This difference is not statistically significant The calculated incidence of dislocations if no treatment had been instituted in the neonatal period is 1 5 per mille in the first population and 2 3 per mille in the second The difference is not statistically significant

Key words CDH hip instability neonatal incidence

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In 1956, Severin calculated the incidence of children with congenital dislocation of the hip in Sweden The children with this diagnosis were traced via the orthopaedic departments throughout the country They were generally more than 1-year-old when diagnosed No treatment had been given during the neonatal period at that time (1936 1945) Severin found that 0 9 per mille of children born alive had CDH He remarked that this figure was a minimal one

During the past 25 years, early treatment of neonatally unstable hips has become standard practice in Sweden Many large materials have been pre-

Table 3 Number of children A With verified instability at the orthopaedic examination during the neonatal period B With stable hips at the orthopaedic examination during the neonatal period C Referred after the neonatal period with unstable hips

Year	No born alive	A	B	C
1960	2 295	1	–	1
1961	2 193	7	1	3
1962	2 468	26	15	1
1963	2 803	40	28	1
1964	3 306	35	38	1
	13 065	109 (8 3 per mille)	82 (6 3 per mille)	7 (0 54 per mille)
1970	3 096	38	79	1
1971	3 363	53	46	5
1972	3 296	52	78	4
1973	3 215	24	56	3
1974	3 304	22	55	2
	16 274	189 (11 6 per mille)	314 (19 2 per mille)	15 (0 92 per mille)

Table 4 Various forms of treatment in children referred for neonatal hip instability and number of children treated

Year	von Rosen splint (+ Frejka pillow)	Only Frejka pillow	Plaster	No treatment	Total
1960	–	1		–	1
1961		7		1	8
1962		32	(4) *	9	41
1963		67	(3) *	1	68
1964		70	–	3	73
		177	(7) *	14	191
1970	44	55	(1)	15	114
1971	54	18	(5) *	27	99
1972	50	33	1 (+ 1) *	46	130
1973	25	20	–	35	80
1974	22	17	–	38	77
	195	143	1 (+ 7) *	161 **	500

The figures in parentheses indicate cases where treatment started with Frejka pillow or von Rosen splint but later changed to plaster These are included in the group according to initial treatment

In this group three children were treated after the neonatal period

been treated with plaster where slight dysplastic changes were still visible at 2 5 years of age

During the years 1970–1974 a von Rosen splint for (4–)6 weeks, followed by a Frejka pillow for another 6(–8)

during the years 1960–1964 and 1970–1974 These children have been examined by a consultant paediatrician once during their first 24 hours and again before leaving the hospital at about 1 week of age The orthopaedic examination was done 1–4 days after the paediatric examination in the majority of the cases When indicated treatment was started immediately after the orthopaedic examination Retrospectively, the material has been classified according to diagnosis, type and results of treatment The 5 year incidence of neonatal instability has been calculated for the two periods The incidence of late (= after the first month of life) diagnosis has been estimated separately

RESULTS

Diagnosis

In Table 2 the total number of infants born alive each year and the total number referred for orthopaedic examination during the same period are presented There is a rapid increase during the early years of the sixties During the later period the total number of patients referred has more than doubled compared with the first

At the orthopaedic examination, the paediatric diagnosis of hip instability has been verified in a number of cases Verified instability means a positive Ortolani sign and/or a positive provoked instability test, or a totally dislocated hip (rare) Table 3 presents the number of children with verified hip instability (A) and the number where instability could not be verified (B) This table also presents the number of children referred after the neonatal period ("missed" cases) (C) None of these had been referred for orthopaedic examination during the period in the maternity ward They were discovered at an age of 6 weeks to 20 months, being mainly referred from the paediatric Health Care Centres

During the first period instability was verified in 109 newborn patients The total population was 13,065, giving an incidence of 109/13,065 = 8 3 per mille The corresponding figure for the second

Table 2 Number of children referred from the maternity ward for orthopaedic examination

Year	No born alive	No referred from maternity ward	Per mille
1960	2295	1	0 4
1961	2193	8	3 6
1962	2468	41	16
1963	2803	68	24
1964	3306	73	22
	13,065	191	14 6
1970	3096	117	37
1971	3363	99	29
1972	3296	130	39
1973	3215	80	24
1974	3304	77	22
	16,274	503	30 9

period is 189/16,274 = 11 6 per mille There is a statistically significant difference between these two figures The number of patients in group B shows an increase from 82/13,065 = 6 3 per mille to 314/16,274 = 19 2 per mille In group C the small difference between the incidence in the first and the second period (0 54 versus 0 92 per mille) is not statistically significant

Treatment

As can be seen from Table 4, during the period 1960 1964 the treatment always started with a Frejka pillow for about 3 months Nearly every child referred to the department had this treatment even if the hips were considered stable at the orthopaedic examination This simple treatment was in seven cases completed with plaster The reason for the treatment with plaster was persisting instability after the Frejka treatment in two cases and persisting X-ray changes interpreted as "dysplasia" in five cases

All hips, including those with plaster, remained stable after this treatment X-ray examinations at 3 months and/or at 1 year or later displayed normal development, except in one case which had



Figure 2 Girl born 24 April 1974 Examinations in the maternity ward 25 April normal hips 28 April positive Ortolani bilaterally 30 April laxitas (?) Examinations by orthopaedic surgeon 29 April 13 May 10 June normal hips 3 July restricted abduction left side 21 August some + leg shortening X ray Acetabular dysplasia + subluxation left side Arthrography Unstable caput femoris left side with cranial dislocation of the labrum (arrow)

and dysplasia (Figure 2) After treatment in plaster the hips became stable with normal X ray appearance

DISCUSSION

Incidence

During the period 1960–1964 8 3 per mille of the newborns were verified as having unstable hips by the orthopaedic specialist compared with 11 6 per mille during the second period This difference is statistically significant There was at the same time no significant change in the number of cases diagnosed after the neonatal period (Table 3)

Bjerkreim (1974) calculated the incidence of neonatally diagnosed cases in south east Norway for the period 1965 1969 to be 8 per mille Cases diagnosed later (> 1 month) amounted to 2 per mille mostly subluxations and dysplasia During the sixties he noticed an increasing number of neonatal as well as late cases when less serious cases were included Palmén (1977, personal communication) has during more recent years (1973–1975) found a large number of cases diagnosed in the age group 1–6 months in all of Sweden Bjerkreim and Palmen feel that this increase is due to the increased activity at the Paediatric Health Care Centres, where much attention has been directed towards the problem of unstable hips in infants

The experience of the Malmö region as presented by Fredensborg (1975) is quite contrary to this There was an increase in the number of neonatal cases in Malmo in the middle of the sixties, but late cases were extremely rare (four in 16 years) The increase in neonatal cases is thought to be due to the fact that many different doctors were involved in the examination of the newborns (Fredensborg et al 1977)

It is generally assumed that the increase in the number of diagnosed cases is the result of intensified diagnostic work and thus not a true increase in hip instability Of course one cannot exclude the possibility that some change in the environment can influence the occurrence of neonatal instability The examination itself may be of some importance

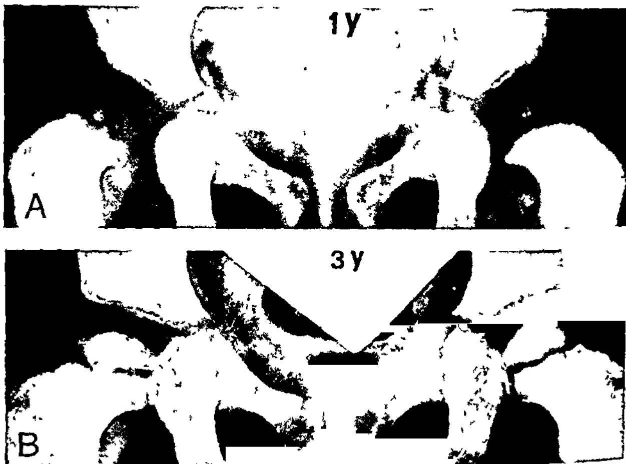


Figure 1 Girl with very unstable hips bilaterally when newborn, even when fixed in a von Rosen splint She was treated from the start in abduction plaster Irregular ossification in the epiphysis and metaphysis was seen for the first time at 11 months (Figure 1 A) X-ray at 3 years (Figure 1 B)

weeks has been the normal treatment in newborn cases with verified instability In six cases the splint was changed to plaster after a short time because of persistent instability at the check-ups In one case sufficient stability could not be attained with a splint, and treatment with plaster was started at once In another case treatment in an abduction splint was prolonged because the X-ray check-up at 4 months showed signs of dysplasia

All cases treated with von Rosen-Frejka, with the exception of those mentioned above, were clinically normal within 12 weeks A final clinical and X ray examination was done at about 4 months

The cases treated in plaster have stable hips except in one bilateral case, where one hip remains unstable even after a series of operative procedures The girl who was treated in plaster from the start is clinically normal but X-ray examination has shown some structural defects in the hip (avascular necrosis?) (Figure 1)

Children, where instability could not be verified, were either treated with Frejka pillows for about 6 weeks (161) or were not given any treatment (143) The examining orthopaedic surgeon selected the cases on an individual basis The children treated with Frejka pillows have all responded satisfactorily Three cases in the non-treated group presented later (6 weeks 4 months) with restricted abduction in the suspected hip Arthrographies of the hips showed instability

ing the risk of missed cases and the simplicity of the treatment when started early this might have been justified A certain degree of over treatment cannot be avoided if the diagnostic criteria cannot be improved

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Changes in obstetric technique could also be a contributing factor Artz et al (1975) have found a higher frequency of neonatal instability among children delivered by caesarean section even if there is a vertex position

Whatever the explanation is, the present study shows that early diagnosis in Uppsala has not been successful in one very important aspect, that is to catch all cases within the first 4 weeks of life (Table 3)

Barlow (1962) reports in his well-known paper that there is a spontaneous tendency towards stability among children with neonatal hip instability. Within 2 months about 88 per cent were stable whether treated or not Severin's figure of 0 9 per mille CDH diagnosed after the first year of life would thus correspond to roughly eight times that in neonatal instability, i e, 7 per mille

In the population from 1960–1964, 8 3 per mille (109/13,065 children) had unstable hips (Table 3) If no treatment has been started this would according to Barlow result in about $\frac{109}{8} \approx 13$ obvious manifestations of CDH A source of error is of course the hips considered stable by the orthopaedic consultant but treated nevertheless (68 children) Seven cases were diagnosed after the neonatal period (Table 3) Altogether at least 20 cases (13 + 7) of CDH would come out of this population, which is about 1 5 per mille Barlow (1962) mentions approximately the same figure (1 55 per mille) The corresponding figures from 1970 1974 are as follows 189 verified cases of instability, $\frac{189}{8} \approx 23$ possible cases of CDH Cases diagnosed after the neonatal period, three (from the non-treated group) (see Table 4) + 15 (referred from Paediatric Health Care Centres) (Table 3) Altogether about 41 cases in a population of 16,274 which is about 2 5 per mille

The apparent difference between the calculated incidence 1 5 per mille versus 2 5 per mille is not a significant one By using this type of calculation it is possible to bridge over the apparent differences in the figures of incidence given by Severin and those found nowadays A calculated figure of about 2 per mille of CDH, if no treatment is instituted neonatally, seem relevant This equals about 1 5 per cent as a reasonable figure for neonatal instability

Treatment

The simple treatment with Frejka pillow and/or von Rosen splint has been successful in the majority of cases Only a few cases needed plaster Only one girl had to be operated upon The treatment period in the von Rosen splint was generally 6 weeks and was followed by the Frejka pillow for the same length of time The good results indicate that longer treatment in the splint is not needed (Emnéus & Undeland 1970) at least if followed by a Frejka pillow for the same time Repeated examinations during the treatment period are necessary in order to check stability In most cases the hip was stable at 2 weeks Too firm a fixation with maximal abduction may be dangerous (Lancet Editorial, 1974) as illustrated by the case primarily fixed in plaster where some structural changes have been observed

Of special interest is the handling of the cases with non-verified instability during the period 1970 1974 Out of a total of 314 cases, about one-half (161) were treated in Frejka pillows and the rest (143) were not treated In the untreated group three subluxations were discovered later (Table 4) In the Frejka-treated group all became normal It is possible that even those three subluxations could have been prevented if the treatment had comprised all cases The existing "over treatment" would in that case have been more extensive Consider-

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Table 1 Pertinent data of the 14 patients with fracture of the femoral prosthesis following total hip replacement

Hospital*)	Name	No	Age	Sex	Weight (kg)	Op date (month/year)	Op to fracture (months)	X ray delay (months)	Site of the fracture (mm)	The other hip	Cement thickness at calcar (mm)	Cement below the prosthesis (mm)	Lateral radio lucent zone (mm)	Appearance of lateral zone (months)	Fract of cement (months)	Position of the stem prosthesis
MGH	LN	1	61	M	93	9/70	41	14	71	THR	1	25	3	13	25	varus
MGH	LM	2	62	F	62	3/73	30	–	79	THR	3	40	4	3	3	varus
MGH	DJ	3	57	F	60	10/72	44	–	85	THR	6	50	–	–	no	neutral
MGH	FI	4	60	F	85	4/70	65	3	90	OA	2	20	5	5	no	varus
SÖS	HB	5	59	M	90	12/70	44	2	83	OA	7	12	5	27	no	neutral
SÖS	CD	6	70	M	98	11/73	14	–	72	Normal	5	30	13	13	no	varus
SÖS	SHI	7	56	M	115	5/69	58	–	84	THR	5	25	2	24	no	varus
SÖS	OG	8	64	M	90	3/69	62	–	66	OA	5	22	5	32	no	varus
SÖS	IH	9	67	M	95	4/70	40	12	81	THR	3	30	3	4	4	neutral
SÖS	SI	10	64	M	102	10/70	46	13	75	OA	3	28	9	6	6	varus
FL	KH	11	81	M	93	4/72	40	–	77	Arthrodesis	–	–	–	–	–	varus
FL	AA	12	73	M	81	11/72	38	6	82	OA	–	–	–	–	–	varus
UHL	HH	13	60	M	84	4/71	66	–	61	THR	0	16	3	2	no	varus
UHL	UH	14	63	F	57	11/73	35	1	100	THR	13	42	2	6	no	varus

*) MGH = Malmö General Hospital
SÖS = Södersjukhuset Stockholm
FL = Falu Lasarett, Falun
UHL = University Hospital, Lund

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FRACTURE OF THE FEMORAL PROSTHESIS IN TOTAL HIP REPLACEMENT ACCORDING TO CHARNLEY

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Departments of Orthopedic Surgery, Malmö General Hospital[1], Malmö, and Södersjukhuset, Stockholm[3], and the Department of Radiology, Malmö General Hospital[2], Malmö Sweden

An analysis of 14 fractures of the stem of the early design of low friction arthroplasty showed a predominance of heavy, bilaterally operated males The total incidence was 0 67 per cent The fractures occurred between 14 months and 5 years postoperatively Every fracture was preceded by radiological signs of loosening caused by varus positioning of the femoral head prosthesis and defective cement support medially at the femoral calcar

Key words hip, arthroplasty

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Fracture of the metallic stem of the femoral head prosthesis in total hip replacement (THR) has been reported for many prosthetic designs (Buchholz & Noack 1973, Charnley 1975, Dandy & Theodorou 1975, Leinbach & Barlow 1973, Martens et al 1974, Wilson & Scales 1973)

The low friction arthroplasty, *ad modum* Charnley, was introduced into Sweden in 1967 A questionnaire sent to the orthopaedic clinics using this method revealed 14 stem fractures All prostheses were of the so-called *first generation* with a flat back They were made of wrought air-melted 316-L stainless steel and all came from the same manufacturer (Thackray, Leeds, England) Revision operations were performed on every hip In no instance was there any suspicion *of infection* at the clinical, radiographic, bacteriological or laboratory investigations

The aim of the present investigation has been to *collect* the clinical details and technical data of the 14 fractures The analysis is based on all hips operated upon according to the method of Charnley during the period 1967–1974 in the orthopaedic departments of the General Hospital in Malmö, Södersjukhuset in Stockholm, the Central Hospital in Falun and the University Hospital in Lund

MATERIAL AND RESULTS

A summary of the pertinent data of the 14 cases is given in Table 1

Diagnosis

In all 14 patients the arthroplasty was a primary operation because of osteoarthrosis of the hip

Age

The age at the primary intervention ranged from 56 to 81 years The average—*61* ± *6 8* years— did not deviate significantly from the average age of all 309 patients undergoing low friction arthroplasty at Malmö General Hospital between 1968 and 1972 (65 5 ± 9 1)

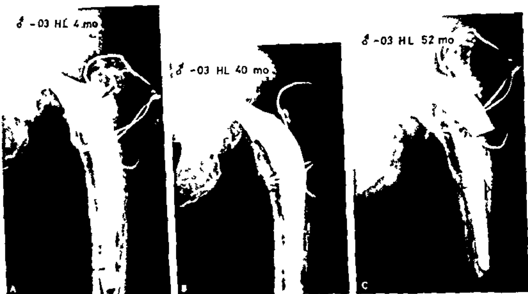


Figure 2 a) Patient no 9, 4 months postoperatively A radiolucent zone is already seen at the lateral proximal border of the stem b) The same patient 40 months postoperatively The fracture was overlooked c) The same patient 52 months postoperatively

Pain and trauma

The result of the primary operation was in every case excellent and all patients walked without a stick In nine patients there was a history of slowly increasing pain in four cases preceded by a moderate trauma. The remaining five patients suddenly felt pain without any kind of trauma or previous discomfort

Torsion of the prosthesis

At the time of this investigation six of the fractured prostheses could be traced Of these, three were not only fractured but their proximal fragments were slightly twisted The proximal fragment of prosthesis no 8 was also bent.

Radiological findings

Level of the fracture The level of the fractures as calculated from the radiographs and corrected for magnification ranged from 61 to 100 mm from the tip of the stem (average 80 ± 10 mm)

Cement support at the femoral calcar The thickness of the cement layer between the metal and the medial cut surface of the femoral neck could be measured in 12 cases and ranged from 0 to 13 mm (average 4 ± 3) In two cases the cement did not contain radio-opaque material and therefore it was not possible to calculate the thickness

Cement support below the tip of the stem prosthesis In the 12 cases where radio opaque cement was used the amount of cement below the tip of the stem was measured and varied between 12 and 50 mm (average 28 ± 11 mm)

All prostheses were rigidly fixed distally in the marrow cavity

Lateral radiolucent zone Loosening of the femoral head prosthesis within the cement bed can be seen as a radiolucent zone at the lateral border of the proximal stem (Figure 2a) This phenomenon could be studied in 11 of the 14 hips In two cases, non opaque cement, and in one case dislocation of the greater trochanter, made calculation impossible

All 11 fractures were preceded by the appearance of a zone of radiolucency, which was first seen between 2 and 32 months postoperatively (average 12 ± 11 months) or between one and 64 months before fracture (average 33 ± 18 months) The maximal width of this zone measured before the fracture occurred, ranged from 2 to 13 mm (average 5 ± 3 mm)

Fracture of the cement Fracture of the cement is another sign indicating a loose stem prosthesis Such a fracture was seen, usually in the vicinity of the tip of the stem, in 4 of the 12 cases before the stem fractured For the reasons previously mentioned, two hips could not be judged

Position of the femoral head prosthesis in the

Table 2 Details of the contralateral hip in the seven patients in the fracture group with bilateral THR

Pat no	Name	The fractured side	The contralateral hip					
		Operation to fracture (months)	Operation to present date—Dec 31, 1976 (months)	Design C=Charnley B=Brunswik	*Cement* thickness at the calcar *(mm)*	Cement below the prosthesis	Position of the prosthesis	Lateral radiolucent zone (mm)
1	EN	41	55	C	1	45	varus	1
2	IM	30	38	B	0	60	varus	none
3	DJ	44	42	C	3	15	*neutral*	1
7	SHL	58	78	C	3	5	varus	2
9	HL	46	71	C	5	55	varus	4
13	HH	66	76	C	2	5	varus	2
14	UH	35	38	C	4	25	varus	1

Sex

Four of the 14 fractures were in women In the total material the female preponderance is about three two The difference in sex distribution between the fractured and the unfractured group is statistically significant ($P < 0.001$) (Table 3)

Weight

In order to compare the weights of patients with and without fractured stems 234 weights were sampled, distributed with regard to age and hospital in the same way as the 10 men in the fracture group The weight of the 10 men was 94.1 ± 9.6 kg as compared with 77.0 ± 12.2 kg in the controls The difference was highly significant ($P < 0.001$)

The other hip

Of the 14 patients seven had a THR, five osteoarthrosis and one an arthrodesis on the contralateral side In only one patient was the other hip normal

Of the 984 patients undergoing THR at Malmo General Hospital and Sodersjukhuset Stockholm between 1967 and 1974 130 were operated on *both sides and in this latter group there were* more fractures of the stem (the difference was significant, $P < 0.01$) In five out of seven cases the fractured side was the first operated

As seen in Table 2 one unfractured hip had been implanted for almost as long a period as the fractured prosthesis, and the other six unfractured hips survived the fractured hips by 3 to 20 months This could not be explained on the basis of superior surgical technique *Only in case* no 3 was the position of the stem prosthesis entirely correct on both sides

Time of fracture

The fractures occurred between 14 months and 5 years and 6 months after the operation (average 44.5 ± 14.4 months) (Figure 1) As 7 out of the 14 fractures were overlooked at one radiographic examination the diagnosis was delayed for 1, 2, 3, 6, 12, 13 and 14 months respectively The average delay was 7.3 months In patient no 4 the fracture was revealed at operation performed because of severe pain and radiographic signs of loosening of the stem prosthesis There was no tendency for the very heavy patients to fracture their prostheses earlier

The hips were revised between 1 month and *1 year and 9 months after the fracture*

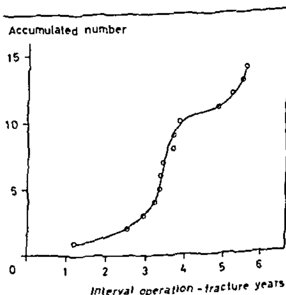


Figure 1 Accumulated number of fractured stems and year after surgery

rounded and strengthened Flanges of the proximal stem are introduced so that the prosthesis is now more able to with stand the medial directed force At the same time the flanges prevent the stem from close bone contact anteriorly or posteriorly thus permitting a thick layer of cement around the whole stem

The incidence 0 67 per cent is signif icantly above ($P < 0\,01$) Charnley's (1975) 0 23 per cent incidence although he excludes fractures occurring less than 3 5 years postoperatively Considering the great risk of overlooking the fracture and the fact that the majority of the fractures appear more than 2 years post operatively there is reason to believe that the true incidence is somewhat greater than that calculated from our observations

The patient at risk is obviously a heavy male patient with bilateral total hip replacements with prostheses placed in varus position having weak proximal and rigid distal fixation

The above mentioned improvements in material and design as well as improve ments in surgical technique especially the valgus position will probably cause a decreased incidence of stem fractures in the future

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shaft Eleven stem prostheses had been placed in a varus position and the remaining three in a neutral position None was placed in valgus

Incidence of fracture

The incidence of fracture calculated with a minimum observation time of 2 years was 0 67 per cent The incidence for females was 0 33 per cent and for males 1 14 per cent (Table 3)

Table 3 Number of fractured and unfractured hips in males and females at the four orthopaedic departments contributing to this investigation

	No fracture	Fracture	Total
Female	1213	4	1217(0 33 %)
Male	860	10	870(1 14 %)
Total	2073	14	2087(0 67 %)

DISCUSSION

Charnley (1975) reported 17 fatigue fractures of the femoral head prosthesis and pointed to the mechanism—poor proximal and rigid distal fixation Our findings agree entirely with this

Possibly excluding defects of the material, fracture of the metal is merely the ultimate fate of a loosened prosthesis When the stem is loose within the cement, the stresses in the stem increase significantly (Amstutz & Markolf 1974) This may cause fatigue or corrosion or a combination of both factors which presumably will not occur in a properly placed and cemented prosthesis

Not one of the failed hips was infected This is in line with the conditions necessary for fracture to occur —rigid distal fixation In an infected femoral shaft, the zone of resorption between bone and cement increases and the femoral prosthesis, together with the surrounding cement, becomes loose within the marrow cavity At the same time, severe pain usually prevents normal use of the hip

At first we expected the patients with fractured stems to be younger than the average That this was not the case may reflect the discrepancy between chronological and biological ages as these patients were all very active The great preponderance of men over women is presumably a reflection of their greater weight—in no case less than 81 kg

Like Charnley (1975), we found an over-representation of bilateral arthroplasties—a most confusing finding By measuring the wear of the socket, Charnley (1975) found no indication that the unfractured side had been noticeably spared Could it be that a normal hip on the contralateral side spares the prosthetic hip, even when the patient is free from symptoms?

The level of the fracture and time of failure are in accordance with Charnley's (1975) findings He also noted the risk of the fracture being overlooked at the radiographic examination, especially if this is performed soon after the fracture has occurred This is not a catastrophe, but in three of our seven overlooked cases the diagnosis was delayed for 1 year or more The result was unnecessary suffering for these patients In cases with THR and pain, especially acute pain, we suggest that the possibility of stem fracture be drawn to the attention of the radiologist so that adequate exposures and projections can be obtained

The observation that the fractured prostheses were twisted shows that important multidirectional forces act on the hip joint Except for the vertical and medial forces, the most important is probably a posterio anterior force acting on the flexed hip joint Here the sharp corners of the flat-backed prosthesis could be weak points

The present development in the field of metallurgy has resulted in a vacuum remelted low-carbon stainless steel with improved properties Also the design of the low-friction arthroplasty has been considerably improved The sharp corners have disappeared and the back is

rounded and strengthened Flanges of the proximal stem are introduced so that the prosthesis is now more able to with stand the medial directed force At the same time the flanges prevent the stem from close bone contact anteriorly or posteriorly thus permitting a thick layer of cement around the whole stem

The incidence 0 67 per cent is significantly above ($P < 0.01$) Charnley s (1975) 0 23 per cent incidence although he excludes fractures occurring less than 3 5 years postoperatively Considering the great risk of overlooking the fracture and the fact that the majority of the fractures appear more than 2 years post operatively, there is reason to believe that the true incidence is somewhat greater than that calculated from our observations

The patient at risk is obviously a heavy male patient with bilateral total hip replacements with prostheses placed in varus position having weak proximal and rigid distal fixation

The above mentioned improvements in material and design as well as improve ments in surgical technique especially the valgus position will probably cause a decreased incidence of stem fractures in the future

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PENETRATION OF A LONG STEM PROSTHESIS INTO THE KNEE JOINT: A COMPLICATION OF TOTAL HIP REPLACEMENT

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The unusual occurrence of penetration of *the stem of a femoral* p[ro]thesis into the knee joint during total hip replacement and the met[hod] used to deal with this complication successfully, without replacing [the] prosthesis is described

Key words long stem prosthesis, penetration knee, complication t[otal] hip replacement

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With the widespread use of total hip replacement, various complications have been reported The entrance of cement into the knee joint and a method of preventing this complication has been reported recently (Hallel et al 1976) It is the purpose of this paper to report an unusual complication also resulting from the use of a long stem prosthesis, viz, penetration of the stem into the knee joint The method of dealing with this complication without replacing the prosthesis is described

CASE REPORT

A 68 year old woman with a markedly symptomatic left hip resulting from gross loosening of a Thompson femoral prosthesis was admitted for total hip replacement on June 6 1976 Because of severe osteoporosis of the femoral shaft a femoral component 28 cm long reaching the supracondylar region was used An anteroposterior radiograph of the knee region performed during operation before injection of the cement, was considered satisfactory (Figure 1)

One week after operation when the pati[ent] started walking she complained of pain [and] crepitus in the left knee which was sligh[tly] swollen and tender The patella could be [felt] rubbing against an irregular surface On [the] lateral roentgenogram it was seen that so[me] acrylic cement had extended into the knee jo[int] and the distal end of the stem of the prosthe[sis] had perforated the anterior cortex at the sup[ra]condylar region with its tip lying against [the] articular surface of the patella (Figure 2)

Arthrotomy of the knee, under tourniquet w[as] performed 3 weeks after the joint replaceme[nt] A small irregular erosion of the articular su[r]face of the patella was noted The excess meth[yl] methacrylate was removed and the cement by[e] on either side of the projecting metallic st[em] was undermined to about one millimetre bel[ow] the level of the anterior cortex The joint sp[ace] was isolated the articular surfaces protect[ed] with wet sponges and a high speed saw bla[de] mounted on a hand saw cutting tangential[ly] was used to cut off the distal end of the pro[s]thesis flush with the anterior cortex A sm[all] grinding stone (7 mm wide) mounted on an a[ir] drill and fine metal files were then used to p[o]lish the cut surface making sure that there w[as] absolutely no contact between it and the p[a]tella (Figure 3) The wound was very thoroug[h]ly irrigated before closure The postoperati[ve]



Figure 1 Anteroposterior radiograph of the left knee at operation There is no evidence of penetration of the knee joint in this view



Figure 3 Lateral radiograph of the knee 4 months after operation showing the final shape of the tip of the stem and the complete absence of contact between it and the articular surface of the patella



Figure 2 Lateral radiograph of the knee 1 week after operation There is acrylic cement in the knee joint and penetration of the stem of the prosthesis with its tip lying against the articular surface of the patella

course was uneventful and the patient regained full symptomless mobility of the knee joint within a short time

DISCUSSION

Loosening of a femoral prosthesis is not an uncommon complication of conventional hip replacement Total hip replacement is the most commonly used form of treatment Very often a long stem prosthesis extending into the supracondylar region has to be used because of marked osteo-

porosis and to avoid fracture of the femur distal of the prosthesis

Due to the natural forward convexity of the femur, which, at times, can be quite marked, protrusion through the porotic anterior cortex should be kept in mind, and, especially when a very long stem is used, both anteroposterior and lateral radiographs should be taken If, in spite of preoperative evaluation, the stem is found to be too long at the time of trial introduction during operation, a shorter one can be used If, however, it is already cemented, as in the present case, replacement of the prosthesis is difficult and since in this case arthrotomy is necessary to remove the cement from the knee joint, the method described offers a simpler and more satisfactory alternative solution

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IMMEDIATE WEIGHT-BEARING AFTER INTERNAL FIXATION OF FEMORAL NECK FRACTURES USING VON BAHR SCREWS

Preliminary Report of a Prospective Clinical Trial

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Osteosynthesis of displaced femoral neck fractures using von Bahr screws was performed in 50 patients Immediate postoperative weight bearing was allowed After a follow-up period of 1 year a high incidence (20 per cent) of early failure (dislocation of the fractures with or without screw movement) was found Analysis of the material showed that the failure rate was influenced by the peroperative reposition of the fracture, especially the valgus/varus position of the caput fragment and the position of the screws

Key words femoral neck fractures, screw osteosynthesis, early weight bearing mechanical failure

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The primary aim when treating femoral neck fractures, especially in the elderly, is to restore the patient's prefracture state in the shortest possible time The patient should be able to start walking exercises immediately after operation preferably with full weight-bearing

The failure rate following conventional internal fixation has up until now been high (for review, see Øhmann et al 1969) It seems clear that the fixation device used for the osteosynthesis affects the stability of the operated fracture, but there is no agreement regarding which type of internal fixation is the best

This paper presents our experience gained from a prospective study of treating patients with displaced, intracapsular femoral neck fractures with internal fixation *ad modum* von Bahr (von Bahr et al 1974) and allowing immediate weight-bearing

PATIENTS AND METHODS

During the period from October 1974 to August 1975, 50 patients with femoral neck fractures were treated in our hospital with internal fixation *ad modum* von Bahr There were 37 female and 13 male patients ranging in age from 15 to 87 years (mean 69 2 years)

All patients were put on tibial traction until the operation Prophylactic anti thrombosis therapy with either Heparin 5000 IU twice a day s c or Dextran 70 were given Concomitant diseases were treated when necessary The internal fixation was performed from 1 to 26 days after admission (mean 2 8 days) (The only patient with a clinical postoperative thrombosis was operated 3 days after admission)

Operative technique The von Bahr technique

for osteosynthesis of *femoral neck fractures* is a screw fixation in which two or *more screws* are inserted Reduction is done with *fluoroscopic* monitoring with the patient on a traction *table* Following reduction the lateral aspect of the proximal femur is exposed The distal screw must be inserted first *A hole is drilled* through the cortical bone and drilling is *continued* to the proximal fragment The screw *should be* placed as steep as possible in the a p view and somewhat dorsal in the collum It seems *important* that the distal screw is *aimed a little* too far distally as the screw when inserted encounters the calcar femoris and may veer off in a cranial direction A second screw is introduced after predrilling approximately 2 cm proximal to the first screw Alternatively *three* screws may be *used the two proximal ones must then be* placed ventrally and dorsally at the same horizontal level Care is taken to ensure that the screws are parallel in both projections (Figure 1) A more detailed description of the technique is given by von Bahr et al (1974) and includes *an outline of the pitfalls of his technique*

Postoperative treatment Postoperative X rays were taken in the operating theatre or shortly after the operation Mobilization with full weight bearing was started as soon as possible and Figure 2 gives the time interval from operation to postoperative walking Physiotherapy was given both in the hospital and after discharge

Mortality No patient died during the operation Postoperative mortality was recorded 1 and 6 months after operation During the first month two patients died One patient died during the *next 5 months*

Complications This includes all complications





Figure 1 X rays showing von Bahr screws used in femoral neck fractures

in the first postoperative month not concerning the fracture The complications are listed in Table 1

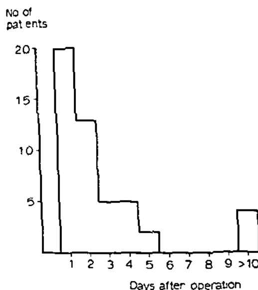


Figure 2 Number of days before weight bearing after operation (one patient died before mobilisation)

Table 1 Postoperative complications

	Complications	No of patients
Local	Deep infection	0
	Superficial infection	1
	Wound haematoma	1
General	Thrombosis/embolism	1
	Cardio pulmonary	3

RESULTS

Every patients was followed closely for the first 6 months after discharge from the hospital All surviving patients were asked to come for a complete examination and X ray review 1 year after the operation

Of the original 50 patients five were dead Eight patients had received and one was waiting for a femoral head prosthesis, these patients were not examined Thirty five patients were examined in our department by one of the authors No information is available concerning the one remaining patient

Hip assessment Stinchfield s modification (Stinchfield et al 1957) of the Judet classification system was used Table 2 shows the Stinchfield system and the criteria for grading clinical results The complete results of the follow up examinations are given in Table 3

Range of movement The range of movement in the operated hips according to Spangfort's scheme is given in Figure 3

Failures During the first year, 8 patients were reoperated with prosthetic replacement due to early mechanical failure of the primary osteosynthesis

Table 2 Stinchfield s hip assessment system Grading of disability according to pain movement and walking ability

PAIN	
Severe—loss of sleep	1
Severe when walking unable to work	2
Moderate—able to do light work	3
Pain after effort—relieved by rest	4
Slight and intermittent	5
Absent	6
MOVEMENT	
Fixed in poor position	1
Fixed in good position	2
0°– 70°	3
70° 140°	4
140°–200°	5
More than 200°	6
WALKING	
Impossible or almost so	1
Short distances only	2
Restricted e g an hour with stick	3
Long distances with stick short without	4
No stick, but limping	5
Normal	6
CLASSIFICATION	
Excellent	16 points or more
Good	12 15 points
Fair	9 11 points
Poor	8 points or less

Table 3 Results of follow-up examination based upon the patient's personal opinion (when available) and the objective hip assessment according to Stinchfield's classification system

	Classification				Unable to give personal opinion
	Excellent	Good	Fair	Poor	
Personal opinion		18	12	1	4
Hip assessment	16	12	5	2	

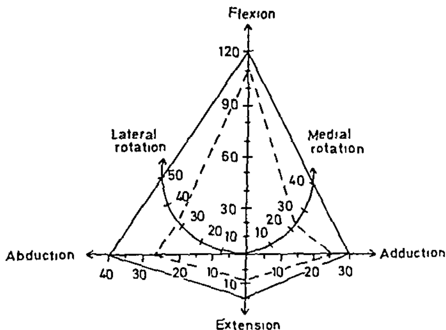


Figure 3 Range of movement in the operated hips according to Spangfort's scheme (left hip turned)

One more patient had screw movement and fracture dislocation before the follow-up examination and is waiting for prosthetic replacement During the follow-up examination one further patient presented with dislocation of the femoral head due to screw movement, but reoperation is not indicated due to the present general condition of the patient Thus, during the first year 10 mechanical failures were recorded giving a failure rate of 20 per cent One patient had necrosis of the femoral head at the time of the follow-up examination

Analysis of the material

The material was analysed to determine the factors which might have influenced the failure rate Table 4 shows the parameters analysed The mechanical failures have then been compared to the rest of the material, in the following called "healed" fractures, and the results are given in Table 4 The Chi-square test was used for the statistical analysis Due to the small number of patients in the different groups, a redistribution, as shown in Table 4, has been made to allow the statistical analysis to be performed

The fracture types found (Garden's classification) seem to be similarly distributed in the "healed" group and in the "failure" group However the number of patients are small and a larger series may be necessary to confirm this distribution

The results of the peroperative reposi-

Table 4 Analysis of the clinical material

		Healed fractures	Failures	Statistical analysis (P values)
Classification of fractures (Garden)	2	6	0	Probably not significant
	3	9	2	
	4	24*	8	
Reposition	Good	27 > 37	2 > 7	$P = 0.05$
	Acceptable	10	5	
	Poor	3	3	
Position of caput	Valgus	24 > 36	2 > 2	$P < 0.05$
	Neutral	12	0	
	Varus	4	8	
Screw position	Good	15 > 16	8 > 9	$P < 0.01$
	Acceptable	1	1	
	Poor	24	1	

* Original X rays are lacking for one patient

tion procedures show that the reposition in the "healed" group is significantly better than in the "failure" group Similarly, the "healed" group shows a more favourable varus/valgus position of the caput fragment compared with the "failure" group

The screw position has also been analysed on the basis of the criteria recommended by von Bahr (von Bahr et al 1974) The "healed" group shows a significantly better screw position than the "failure" group

DISCUSSION

Analysis of our material indicates that the primary grade of displacement was not important as a factor causing mechanical failure, whereas the operative reduction, especially the valgus/varus position of the femoral head were of significant importance Similarly, the analysis indicates that poor screw position gives a higher failure rate

von Bahr has reported screw movement in 9.5 per cent of his patients Pseudarthrosis was also found in 9.5 per cent of his patients but he has not indicated whether this group of patients is the same as the group with screw movement The explanation for the high failure rate (20 per cent) in our material compared with the probable low failure rate in von Bahr's series is not quite clear In our material the patients were allowed weight-bearing from the first postoperative day, whereas von Bahr seems to have been more restrictive as regards weight bearing Furthermore, von Bahr seems not to have excluded impacted fractures (Garden type 1) from his study as we have done On the other hand, the results of the reposition procedure and the operative fixation (screw position) seem to be better in his material These factors may explain the differences in failure rates

The high incidence of mechanical failure is unacceptable If either reduction or screw position is unsatisfactory based on the peroperative fluoroscopic view, it seems justified to advocate either a re-reposition and a new osteosynthesis or a primary prosthetic replacement An

earlier retrospective report from this department (Soreide et al 1975) indicates that primary prosthetic replacement therapy in the elderly carries the same low mortality and morbidity rates as the internal fixation reported in this paper

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UNSATISFACTORY RESULTS OF EARLY TREATMENT OF INFANTS WITH UNSTABLE HIPS AT BIRTH

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Among 19,864 infants born in Trondheim between 1 May 1969 and 31 December 1974 instability of the hip joint was diagnosed in 378 (19 03 per thousand live born) All infants were treated with a Frejka cushion splint usually for 3 months In spite of this early treatment 31 infants (8 2 per cent) developed subsequent signs of CDH In 20 children the diagnosis of CDH was based solely on radiological criteria while 11 children also displayed clinical abnormalities most often restricted abduction of the hip joint The prenatal and perinatal condition of the 31 children with persistent signs of CDH in spite of early treatment was compared with that of the 347 children who showed no obvious signs of CDH The former group of patients had a relatively high frequency of hip abnormalities in their families and an increased frequency of breech presentation at birth concomitant foot deformities and instability of the hip joint also on the eighth day after birth It is suggested that infants with unsatisfactory results from the early treatment of unstable hips constitute a separate clinical entity and an especially severe form of CDH

Key words hip dislocation congenital early treatment unsatisfactory results

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The purpose of the present paper is to present the results of a detailed analysis of a group of children with unstable hips at birth in whom early therapy seemed to have failed

PATIENTS AND METHODS

Among 19 864 infants born in Trondheim between 1 May 1969 and 31 December 1974 instability of the hip joint was diagnosed in 378 (19 03 per thousand live born) A detailed description of the patients has been given in a previous paper (Cyvin 1977 b)

All infants with unstable hips were treated with a Frejka cushion splint usually for 3 months In 347 patients (group B) the results of this early treatment were considered satisfactory

Thirty-one infants (*group A*) subsequently developed signs of congenital *dysplasia* of the hip joint (CDH) The diagnosis of CDH was made *before 3 months* in two patients between 3 and 6 months in nine from 7 to 12 months in

earlier retrospective report from this department (Søreide et al 1975) indicates that primary prosthetic replacement therapy in the elderly carries the same low mortality and morbidity rates as the internal fixation reported in this paper

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UNSATISFACTORY RESULTS OF EARLY TREATMENT OF INFANTS WITH UNSTABLE HIPS AT BIRTH

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Among 19 864 infants born in Trondheim between 1 May 1969 and 31 December 1974 instability of the hip joint was diagnosed in 378 (19 03 per thousand live born) All infants were treated with a Frejka cushion splint usually for 3 months In spite of this early treatment 31 infants (8 2 per cent) developed subsequent signs of CDH In 20 children the diagnosis of CDH was based solely on radiological criteria while 11 children also displayed clinical abnormalities most often restricted abduction of the hip joint The prenatal and perinatal condition of the 31 children with persistent signs of CDH in spite of early treatment, was compared with that of the 347 children who showed no obvious signs of CDH The former group of patients had a relatively high frequency of hip abnormalities in their families and an increased frequency of breech presentation at birth concomitant foot deformities and instability of the hip joint also on the eighth day after birth It is suggested that infants with unsatisfactory results from the early treatment of unstable hips constitute a separate clinical entity and an especially severe form of CDH

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Thirty-one infants (group A) subsequently developed signs of congenital dysplasia of the hip joint (CDH) The diagnosis of CDH was made before 3 months in two patients between 3 and 6 months in nine from 7 to 12 months in

Table 1 The criteria for the subsequent diagnosis of CDH in 31 children with unstable hips at birth

Criteria of CDH	No of patients	
Radiological only		
Sloping of the acetabular roof and/or indistinctly marked lateral margin	11	
Subluxation or luxation	3	
Pathological acetabulum + subluxation	5	
Retarded development of the femoral epiphysis	1	20
Clinical + radiological (subluxation in all)		
Restricted movements of the extremity	5	
Restricted movements + shortening	6	11
Total		31

Table 2 Prolonged therapy of 31 children with unstable hips at birth

Type of treatment	Duration in months 0–3	4–6	> 6	No of patients
Abduction splint	15	13	3	31
Plaster cast	4	13	14	31
Operation				5

twelve and after 12 months in eight Table 1 shows the criteria on which the diagnosis of CDH was based

In all patients in group A, prolonged treatment was instituted at the Orthopaedic Department of the Regional Hospital Table 2 shows the type and duration of the different therapeutic procedures

Information regarding the prenatal and perinatal condition of the patients was obtained from maternity unit records The following data were recorded

a) Family history of abnormalities of the hip joint and other malformations

b) The age and parity of the mother and history of previous abortions or stillbirths

c) Abnormalities of pregnancy such as proteinuria, elevated blood pressure signs of infection diabetes Rhesus immunisation administration of drugs X-ray examination or therapy and studies of placental function

d) Duration of pregnancy estimated from the date of the last menstrual period

e) The course of delivery including type of presentation, special procedures (oxytocin induction, rupture of the membranes, forceps or vacuum extraction, caesarean section), and the following complications bleeding pathological foetal heart beat, meconium stained liquor duration of delivery exceeding 24 hours, and efflux of liquor more than 12 hours before delivery

f) The birth weight, birth length head circumference, and Apgar score of the child and pathological findings such as signs of dysmaturity, hypotonia irritability, jaundice and malformations

g) The weight of the placenta and any macroscopic abnormalities, especially infarcts and calcification

h) Date of examination, name of examiner side affected, degree and duration of the instability of the hip and treatment instituted

Information regarding the subsequent management of the cases of CDH was obtained from the *records of the Orthopaedic Department* of the Regional Hospital

The collected data were processed in a UNIVAC 1108 computer at the Computing Centre of the University of Trondheim The mean values for group A and group B were computed Differences of means were tested by the t test and P values below 0 05 were regarded as statistically significant When indicated regression curves and confidence limits were computed A correlation coefficient of greater than 0 75 was regarded as significant

RESULTS

Table 3 shows the frequency of hip joint abnormalities in the families of infants with unsatisfactory and satisfactory results from the early treatment of unstable hips CDH occurred significantly more often in group A families than in those of group B ($P < 0\ 01$)

There was no significant difference in the incidence of previous abortions or stillbirths between mothers of group A and those of group B

There were no significant differences between infants in group A and those in group B in the incidence of the following gestational complications emesis, early and late bleeding, polyhydramnions anaemia pelvic instability, neurological

Table 3 Hip joint abnormalities in the families of 31 infants with persistent signs of CDH in spite of early treatment (group A) and in those of 347 early treated infants without obvious persistent abnormalities (group B)

Relatives	Group A			Group B		
	CDH	Others	Total	CDH	Others	Total
1st degree	5	0	5	34	2	36
Others	6	0	6	29	12	41
Total	11 (35.5 %)	0	11	63 (18.2 %)	14	77

Table 4 Course of labour in mothers of 31 infants with persistent signs of CDH in spite of early treatment (group A) and in mothers of 347 early treated infants without obvious persistent abnormalities

Course of labour	Group A		Group B	
	No	%	No	%
Spontaneous	16	51.6	243	70.0
Oxytocin induction	11	35.5	56	16.1
Rupture of membranes	2	6.5	25	7.2
Vacuum extraction forceps	3	9.7	25	7.2
Caesarean section	0	0.0	20	5.8

symptoms, blood pressure above 140/90, proteinuria, and infections

There was no significant difference between mothers of group A and those of group B in the use of the following drugs antiemetics, diuretics, antibiotics, hormones, and sedatives

Table 4 shows the frequency of special procedures during the delivery of mothers in group A and those in group B Spontaneous delivery occurred significantly more often in group B than in group A, whereas oxytocin induction was instituted more often in mothers of group A than in mothers of group B The different incidence of caesarean section in the two groups is not statistically significant

There was no significant difference in

Table 5 The birth presentation of 31 infants with persistent signs of CDH in spite of early treatment (group A) and of 347 early treated infants without obvious persistent abnormalities

Birth presentation	Group A		Group B	
	No	%	No	%
Left occiput anterior	19	61.3	198	57.1
Right occiput anterior	2	6.5	81	23.3
Breech left sacrum anterior	4	12.9	41	11.8
Breech right sacrum posterior	3	9.7	13	3.7
Breech unspecified	0	0.0	1	0.3
Footling left sacrum anterior	1	3.2	2	0.6
Footling right sacrum posterior	1	3.2	2	0.6
Left brow	0	0.0	8	2.3
Unspecified	1	3.2	1	0.3

the complications of delivery between mothers of group A and those of group B.

In Table 5 can be seen the birth presentation of infants in group A and group B. The total frequency of breech presentation was 29.0 per cent in group A and 17.0 per cent in group B. The difference is statistically significant on the basis of the A > B-hypothesis, but not on the basis of the A # B-hypothesis.

Some of the characteristics of infants in group A and group B are shown in Table 6. Foot deformities occurred more frequently in group A than in group B ($P < 0.01$), otherwise there was no significant difference between the two groups.

Table 7 shows the sex distribution and birth rank of infants with satisfactory and unsatisfactory results from early treatment. There was no significant difference in the sex distribution, but birth rank one occurred significantly more often in group B than in group A when the B > A-hypothesis was adopted.

From Table 8 can be seen the incidence of perinatal asphyxia by the Apgar scores. There was no significant difference between infants in group A and those in group B.

Table 9 shows the results of the luxation provocation test on the first or second day of life and on the examination at the age of 1 week. Results of the first examination are similar in groups A and B. On the last examination 29 per cent of infants in group A and 11.5 per cent of infants in group B showed persistent instability of the hip joint. The difference is statistically significant ($P < 0.01$).

Table 6. Some characteristics of 31 infants with persistent signs of CDH in spite of early treatment (group A) and of 347 early treated infants without obvious persistent abnormalities (group B)

Characteristics	Group A		Group B	
	No	%	No	%
Foot deformities	3	9.6	6	1.7
	Mean	S.D.	Mean	S.D.
Gestation (days)	284.80	12.32	286.14	10.35
Birth weight (g)	3644.88	490.53	3618.24	498.21
Birth length (cm)	51.28	1.90	50.93	2.07
Head circumference (cm)	35.44	1.15	35.56	1.73
Weight of placenta (g)	692.06	153.50	672.82	137.84

Table 7. Sex distribution and birth rank in 31 infants with persistent signs of CDH in spite of early treatment (group A) and in 347 early treated infants without obvious persistent abnormalities (group B)

	Group A		Group B		Total	
	No	%	No	%	No	%
Boys	7	22.6	86	24.8	93	24.6
Girls	24	77.4	261	75.2	285	75.4
Total	31	100.0	347	100.0	378	100.0
Birth rank one	11	35.4	178	51.3	189	50.1

Table 10 shows the correlation between the side affected at birth and the lateralisation of subsequent pathological findings in the hip. It can be seen that in 12 infants (38.7 per cent) there was a positive correlation between the findings at birth and the late diagnosis of dysplasia.

Table 8. Apgar scores of 31 infants with persistent signs of CDH in spite of early treatment (group A) and of 347 early treated infants without obvious persistent abnormalities (group B)

Apgar scores at the age of 5 min	Group A		Group B		Total	
	No	%	No	%	No	%
0–4	0	0.0	6	1.7	6	1.5
5–8	0	0.0	4	1.2	4	1.1
9–10	31	100.0	337	97.1	368	97.4
Total	31	100.0	347	100.0	378	100.0

Table 9. Results of the examination of the hip joint at birth in 31 infants with persistent signs of CDH in spite of early treatment (group A) and in 347 early treated infants without obvious persistent abnormalities (group B)

Side affected	Group A		Group B		Total	
	No	%	No	%	No	%
Right	10	32.3	93	26.8	103	27.2
Left	12	38.7	138	39.8	150	39.7
Bilateral	9	29.0	116	33.4	125	33.1
Total	31	100.0	347	100.0	378	100.0
Stable on first examination	1	3.2	11	3.2	12	3.2
Persistent instability after 1 week	9	29.0	40	11.5	49	13.0

Table 10. Correlation between the side affected at birth and the localisation of the subsequent dysplasia subluxation in 31 infants with persistent signs of CDH in spite of early treatment

Unstable hip at birth	Late dysplasia or subluxation			Total
	Right	Left	Bilateral	
Right	5	3	2	10
Left	3	3	6	12
Bilateral	3	2	4	9
Total	11	8	12	31

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TRABECULAR ARCHITECTURE OF THE KNEE JOINT

HIDEO TAKECHI

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University Medical School, Okayama Japan.

The trabecular architecture of the human knee joint was studied three dimensionally by microradiographs The trabecular arrangement of the two condylar wheels of the femur was divided into five types The trabeculae are so arranged that both condyles are able to adjust to mechanical compression and rotary movement In the tibia, each trabecular arrangement has a different mechanical function The epiphyseal line can be considered a laminated structure interposed between the compressive forces acting from the articular surface and the forces supporting the architecture of the metaphysis The mechanics and kinematics of the trabecular architecture are discussed

Key words trabecular architecture, knee joint, microradiographs

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Various attempts have been made to analyze the trabecular structure of the upper end of the femur The oldest model is Ward's triangle (trigonum internum femoris) described in 1838 in which it was likened to a derrick supporting a load The trabecular architecture of the femoral head and neck has been used in biomechanical analysis of osteoarthritic alterations of the hip, internal fixations of fractures, osteotomy of the proximal femur and in total hip replacement However, the trabecular architecture of the knee joint has not been analyzed in a similar fashion The purpose of this paper is to describe knee trabecular architecture as observed by microradiographs

MATERIAL AND METHODS

Six complete adult knee joints were obtained from amputated limbs The patients ranged from 30 to 60 years of age The specimens were fixed in 10 per cent formalin for 1 week, and the soft tissues were removed from the femur, tibia and patella The specimens were washed in water for 24 hours, defatted in trichlorethylene for 72 hours, dehydrated for 24 hours in a graded series of 70, 90 and 99 per cent ethyl alcohol, dried at room temperature for 4 hours and embedded in polyester resin The embedded specimens were cut into serial sections, using a high speed cutter, in the horizontal, sagittal and frontal planes The sectioned specimens were treated with 2 per cent sodium hypochlorite solution for 20 minutes to remove the protein The embedded resin was removed manually and the bone sections were examined by microradiography The microradiographic apparatus used was type CMB, Nippon Soft-X Co (Tokyo) Roentgenograms were taken at 30 KVP, 2 5 mA for 90 seconds at a distance of 70 cm

RESULTS

The femur and tibia trabeculae showed different patterns of arrangement on either side of the epiphyseal line on sagittal sections Below the epiphyseal line in the femur, the trabeculae were gen-

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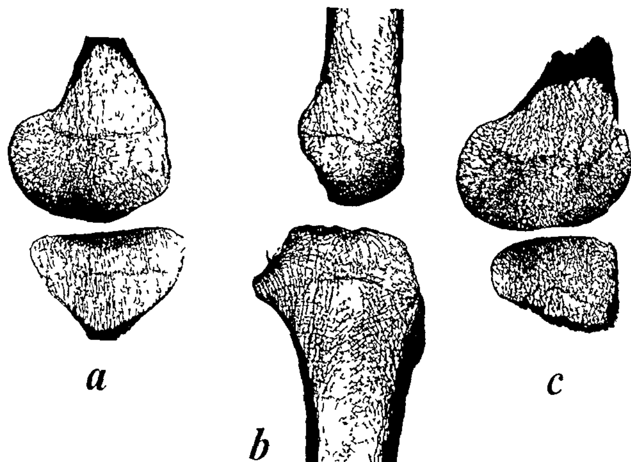


Figure 1 Sagittal sections of the knee joint, 40-year old female a medial section, b middle section, c lateral section

erally arranged perpendicular to the articular surface In the medial and lateral condyles, dense orientations of the trabeculae ran directly from the middle and somewhat posterior region of the epiphyseal line to the posterior joint surface This trabecular orientation had an anterior inclination of 20° to the femoral axis Trabeculae located posterior to this region were arranged perpendicular to the joint surface in both condyles However, trabeculae located in the anterior area displayed different patterns in the medial and lateral condyle Trabeculae in the medial condyle were mainly arranged perpendicular to the joint surface toward the epiphyseal line These trabeculae were fine and dense for 5 10 mm from the articular surface, and then thick and coarse toward the epiphyseal line These thick and coarse trabeculae were connected by fine transverse trabeculae In the lateral condyle, the trabeculae were also arranged perpendicular to the articular surface but did not reach the epiphyseal line, and these trabeculae were consistently thick and dense No definite trabecular orientation was present in the region surrounded by the posterior trabeculae, the anterior trabeculae and the epiphyseal line

In these sagittal sections the profile of the medial condyle was more circular and the lateral condyle was more ellipsoidal in shape (Figure 1) As the wheels of both condyles were not parallel to the sagittal plane, both condyles were sectioned in the plane parallel to the wheel The medial sections of the medial condyle (Figure 2) were more circular but at the center of the wheel a more ellipsoidal contour was present In cut-sections



Figure 2 Sections of the condylar wheels, 36 year old male a medial condyle b lateral condyle

near the intercondylar notch the contour was ellipsoid-shaped with a flattened anterior surface The contour of the lateral condyle was more smoothly ellipsoidal The trabecular arrangement of the condylar wheels was similar in both condyles The previously described trabeculae with 20° inclination were also evident in both condyles From the patellar surface of the condyles, the fine and dense perpendicular trabeculae were arranged toward the epiphyseal line These trabeculae were arranged more horizontally in the medial than in the lateral condyle In the central area of these wheels the trabeculae formed an irregular network These trabeculae were thick and coarse in the medial condyle but fine and dense in the lateral condyle The irregularly shaped intercondylar notch showed articular cartilage in the anterior half The trabeculae were perpendicular to the surface in the anterior half but formed a network in the posterior half Above the epiphyseal line, the trabeculae were parallel to the femoral axis in both condyles However, sections of the intercondylar notch showed two groups of trabeculae crossing each other those running from the antero-superior cortex to the postero-inferior cortex and those from the postero-superior cortex to the antero-inferior cortex

Sagittal sections of the patella showed two groups of trabeculae (Figure 3) The first group was arranged perpendicular to the articular surface in a rather postero-anterior direction and the second group ran along the anterior contour at intervals of 4 mm

Trabeculae of the tibia were arranged perpendicular to the joint surface in both condyles and they were parallel to the tibial axis However, sagittal sections of the middle area of the tibial tuberosity showed four definite groups of trabecular arrangement (1) from the tibial tuberosity to the posterior articular surface, (2) from the posterior cortex to the posterior articular surface and eminentia (3) from the tibial tuberosity downward to the posterior cortex and (4) from the anterior cortex upward to the posterior margin of the metaphysis The trabeculae of the last group were finer than those of the other groups, and the latter two groups crossed each other in the metaphysis

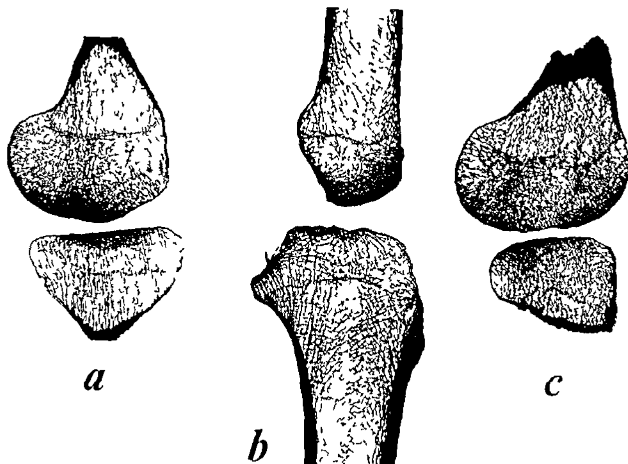


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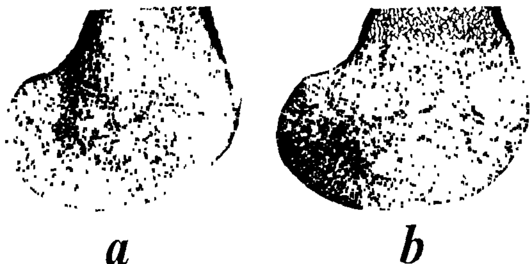


Figure 2 Sections of the condylar wheels, 36 year old male a medial condyle, b lateral condyle

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Sagittal sections of the patella showed two groups of trabeculae (Figure 3). The first group was arranged perpendicular to the articular surface in a rather postero-anterior direction and the second group ran along the anterior contour at intervals of 4 mm

Trabeculae of the tibia were arranged perpendicular to the joint surface in both condyles and they were parallel to the tibial axis However, sagittal sections of the middle area of the tibial tuberosity showed four definite groups of trabecular arrangement (1) from the tibial tuberosity to the posterior articular surface, (2) from the posterior cortex to the posterior articular surface and eminentia, (3) from the tibial tuberosity downward to the posterior cortex and (4) from the anterior cortex upward to the posterior margin of the metaphysis The trabeculae of the last group were finer than those of the other groups, and the latter two groups crossed each other in the metaphysis

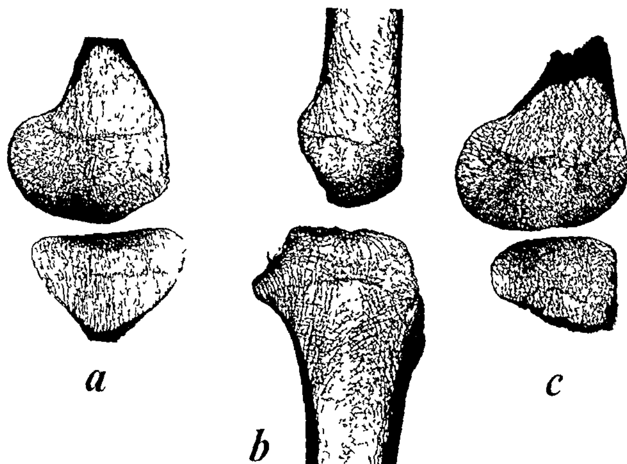


Figure 1 Sagittal sections of the knee joint 40-year-old female a medial section, b middle section c lateral section

erally arranged perpendicular to the articular surface In the medial and lateral condyles, dense orientations of the trabeculae ran directly from the middle and somewhat posterior region of the epiphyseal line to the posterior joint surface This trabecular orientation had an anterior inclination of 20° to the femoral axis Trabeculae located posterior to this region were arranged perpendicular to the joint surface in both condyles However, trabeculae located in the anterior area displayed different patterns in the medial and lateral condyle Trabeculae in the medial condyle were mainly arranged perpendicular to the joint surface toward the epiphyseal line These trabeculae were fine and dense for 5 10 mm from the articular surface and then thick and coarse toward the epiphyseal line These thick and coarse trabeculae were connected by fine transverse trabeculae In the lateral condyle, the trabeculae were also arranged perpendicular to the articular surface but did not reach the epiphyseal line, and these trabeculae were consistently thick and dense No definite trabecular orientation was present in the region surrounded by the posterior trabeculae, the anterior trabeculae and the epiphyseal line

In these sagittal sections the profile of the medial condyle was more circular and the lateral condyle was more ellipsoidal in shape (Figure 1) As the wheels of both condyles were not parallel to the sagittal plane both condyles were sectioned in the plane parallel to the wheel The medial sections of the medial condyle (Figure 2) were more circular but at the center of the wheel a more ellipsoidal contour was present In cut-sections

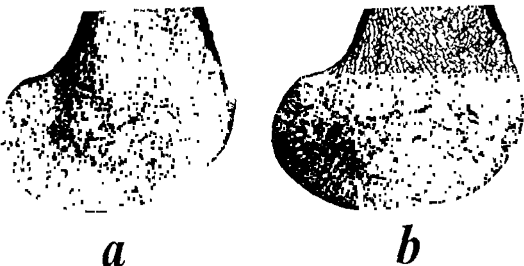


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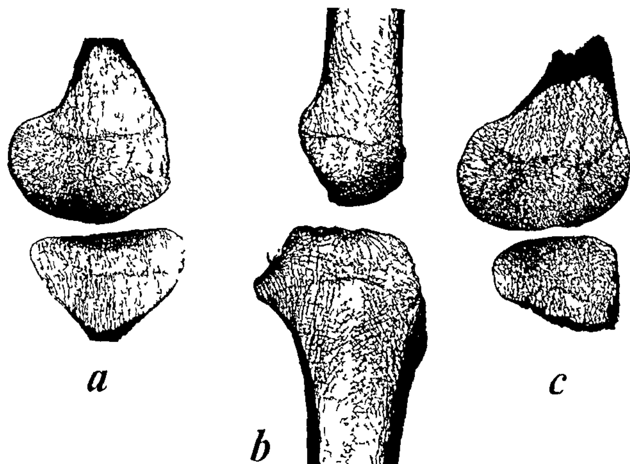


Figure 1 Sagittal sections of the knee joint 40 year-old female a medial section b middle section c lateral section

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Figure 5 Horizontal sections of the femur, 35 year-old male a section below the epiphyseal line, b section above the epiphyseal line



Figure 6 Horizontal sections of the tibia 35-year-old male a section above the epiphyseal line, b section below the epiphyseal line

surface and the trabeculae were arranged parallel to the outer contour of the condyles The trabeculae perpendicular to the posterior surface were fine and dense near the joint surfaces, but thick and coarse in the region between the joint surfaces The second type of trabecular arrangement was found near the patellar surface and was oriented parallel to the anterior contour, crossing the first type of trabeculae The third type of trabecular arrangement radiated from the intercondylar notch out to both sides, crossing the first type of trabeculae The central area of the femur surrounded by the first, second and third trabecular arrangements was rather coarse and irregularly oriented The fourth type of trabecular arrangement consisted of fine and short trabeculae radiating from both collateral ligament attachments

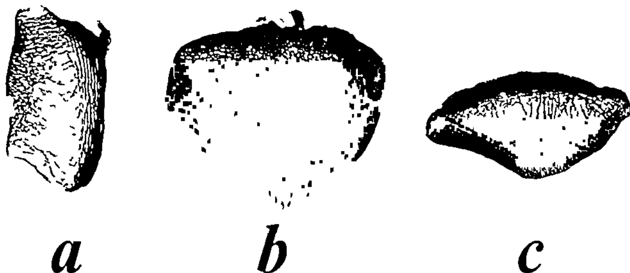


Figure 3 *Sections of the patella a sagittal section 40 year old female, b frontal section 60 year old male, c horizontal section 34-year-old male*

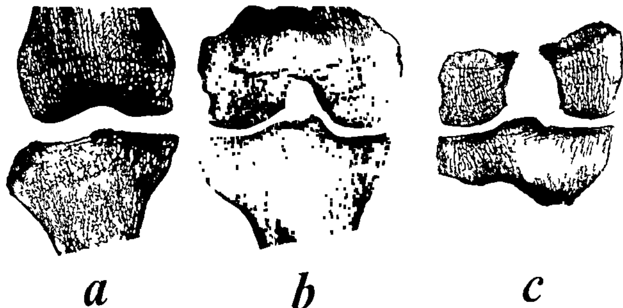


Figure 4 *Frontal sections of the knee joint 60 year-old male a anterior section b middle section c posterior section*

In frontal sections of the femur and tibia, the trabeculae were usually arranged perpendicular to the joint surface and parallel to the bone axis (Figure 4) They were thicker and coarser near the epiphyseal line from the joint surface, and finer and denser toward the metaphysis Other trabeculae radiated from the intercondylar notch toward both condyles

Frontal sections of the patella showed an irregular trabecular network (Figure 3)

Horizontal sections of the femoral condyles showed the direction of the condylar wheels (Figure 5) The patellofemoral articulation was also observed in these sections All horizontal sections of the femoral condyle showed four patterns of trabecular orientation The first pattern was from the posterior articular surface of both condyles to the patellar



Figure 5 Horizontal sections of the femur 35-year old male a section below the epiphyseal line, b section above the epiphyseal line



Figure 6 Horizontal sections of the tibia 35 year old male a section above the epiphyseal line, b section below the epiphyseal line

surface, and the trabeculae were arranged parallel to the outer contour of the condyles. The trabeculae perpendicular to the posterior surface were fine and dense near the joint surfaces, but thick and coarse in the region between the joint surfaces. The second type of trabecular arrangement was found near the patellar surface and was oriented parallel to the anterior contour, crossing the first type of trabeculae. The third type of trabecular arrangement radiated from the intercondylar notch out to both sides, crossing the first type of trabeculae. The central area of the femur surrounded by the first, second and third trabecular arrangements was rather coarse and irregularly oriented. The fourth type of trabecular arrangement consisted of fine and short trabeculae radiating from both collateral ligament attachments.

Horizontal sections of the patella showed three types of trabecular arrangement The first was fine, ran antero-posteriorly and was perpendicular to the joint surface The second trabecular group was arranged along the anterior contour at intervals of about 4 mm The third type was present mainly at the lateral joint surface and was arranged parallel to the contour at intervals of 4–5 mm (Figure 3)

Horizontal sections of the tibia near the articular surface showed a fine trabecular network with a transverse orientation in the anterior area and a radial orientation in the posterior area (Figure 6) Four groups of trabecular arrangement were found in sections containing the tibial tuberosity The first group ran from the lateral cortex to the tibial tuberosity, the second from the postero-medial cortex to the tibial tuberosity, the third from the posterior cortex to the antero-lateral cortex and the fourth from the posterior cortex to the antero-medial cortex

DISCUSSION

The architecture of cancellous bone has been studied for the past one hundred years In 1867, Meyer observed the architecture of the upper end of the femur and described two kinds of trabecular arrangement, viz, tension trajectories and pressure trajectories which intersected at right angles In 1869, Wolff demonstrated the relation between architecture and function of bone and emphasized that the major trabecular patterns intersect at right angles (orthogonality) Roux (1895) agreed with Wolff's opinion and stated that cancellous bone is built trajectorially

These theories have been called "the trajectorial theory" The term "trajectory" has been used for a single bone trabecula with a definite orientation corresponding to stress Gebhardt (1910) and Petersen (1927) studied the same subject

However, in 1920, Jansen pointed out that most of the previous investigators considered that the static pressure of the body weight played the predominant role in bone formation He suggested that muscle tension had an equally strong deciding influence on the architecture of cancellous bone In 1929, Carey stated that the architecture of cancellous bone was the result of pressure factors from muscle action rather than the static pressure of body weight Both Jansen and Carey believed that the major trabeculae do not intersect at right angles

Recently, Pauwels (1973) proved that the classical trajectorial theory is a valid principle for bone architecture in the upper end of the femur

On the other hand, in 1922, Triepel (1922 a) stated that the internal bone architecture was in basic harmony with the outer contour though further modifications were due to mechanical stress Triepel's theory was that the trabeculae supported the outer contour of the bone

Although most of these studies were carried out on the upper end of the femur, it appears to have been accepted that trajectorial architecture was observed in every cancellous bone Observations of the trabecular patterns in the lower end of the femur have only been reported by a few authors Koch (1917) studied trabecular architecture in this part using a few three dimensional sections and concluded that all trabeculae arising from the joint surface were perpendicular to it Jansen (1920) observed the diverging trabeculae radiating from the intercondylar notch and suggested that these might be the result of some rotational force acting on the tibia Triepel (1922 b) found that the cut-surface of the femoral condyles displayed two trabecular orientations one running straight from the posterior area diverging to the distal anterior region and the other run-

ning from the anterior area curving along the outer contour of the condyles to the posterior area He thought that these orientations corresponded with the cut surfaces of his "contour-forming trabecular sheets". Maquet (1976) studied the trabecular architecture of the femoral condyles using a photoelastic model of frontal and horizontal planes as well as horizontal X-ray pictures and supported the trajectorial theory Descriptions of the trabecular architecture in the frontal and horizontal plane by Koch, Jansen, Triepel and Maquet were almost the same

The present study also found trajectories in the frontal and horizontal sections of the femoral condyles as previous investigators have mentioned These findings suggest that the static pressure of the body weight is important and support the trajectorial theory as did Maquet's findings However, the precise architecture of both the condylar wheels should be studied in the sagittal plane in order to analyze the relation between their architecture and function In the usual lateral view of X-ray examinations both femoral condyles and the intercondylar notch are superimposed so that the detailed trabecular architecture cannot be obtained By contrast, the trabecular architecture of the condylar wheels can be revealed by microradiographic techniques using the recent advances in calcified material preparation The present study showed that the internal structure of the condylar wheels is influenced by rotary movement in the sagittal plane Moreover, the plane of the cross-section was made parallel to the direction of each condylar wheel of the femur in this study because both the condylar wheels of the femur induce rotary movement of the knee joint The five trabecular arrangements in the sagittal sections are shown in Figure 7

1 The central network just below the epiphyseal line These trabeculae were

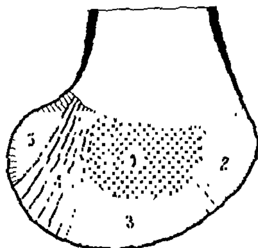


Figure 7 Schematic illustration of the trabecular arrangement of the condylar wheel 1 Central network 2 Anterior perpendicular trabeculae 3 Inferior perpendicular trabeculae 4 Trabeculae with an anterior inclination 5 Posterior trabeculae

the same as the transverse trabeculae observed on vertical cut surfaces radiating from the intercondylar notch to both condyles in both horizontal and frontal sections

2 The perpendicular trabeculae running from the anterior patello-femoral articular surface to the central network

3 The perpendicular trabeculae at the bottom of the wheels They run from the tibio-femoral weight-bearing surface to the central network

4 Trabeculae with an anterior inclination of 20°

5 The fine and dense trabeculae seen at the posterior margins of both condyles

Trabecular arrangement 1 can be likened to the axis of a wheel and trabecular arrangement 3 can be compared to the spokes of a wheel Arrangement 2 resists compression exerted by the patella, arrangement 4 supports both the weight-bearing-force and the outer contour of the bone, and arrangement 5 supports the outer contour Some trabeculae perpendicular to the joint surface prob-

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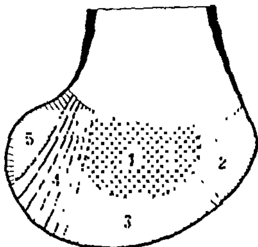


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ably do not radiate from the axis as the shape of the condylar wheels is not circular. Nevertheless, the present findings demonstrate that both condyles are adjusted to mechanical compression and the rotary movements of the condylar wheels. From these observations it would seem to be difficult to adapt the trajectorial theory to explain the architecture of the condylar wheels.

The present results further indicate that the trabeculae perpendicular to the joint surfaces of both tibial condyles support compression from both condylar wheels of the femur. However, sections containing the tibial tuberosity present a different trabecular arrangement. In 1900, Albert described the trabecular arrangement in these areas as consisting of two groups of trabeculae, viz., an anterior band from the lower posterior cortex to the eminentia and the anterior articular surface, and a posterior band from the lower anterior cortex to the eminentia and the posterior articular surface. He also mentioned that these two bands cross each other at right angles. His study supported the trajectorial theory. The present study also showed trajectories but the trabecular arrangement can be divided into four groups (Figure 8). The first and third groups are constructed to resist tension from the M. quadriceps femoris at the tibial tuberosity and the fourth group to resist tension from the hamstrings. The second tabecular group as well as the posterior half of the first group support compression by acting on the articular surface. Thus, each trabecular arrangement has a different mechanical function. The first and second groups seen in horizontal sections support tension exerted at the tibial tuberosity and the third and fourth groups support the outer contour of the bone.

It was also shown that there are fine and dense trabeculae converging toward the epiphyseal line from the metaphysis

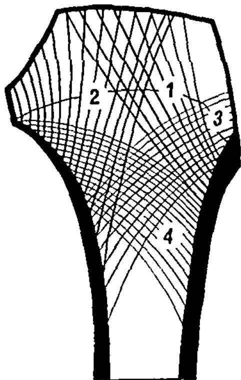


Figure 8. Schematic illustration of the trabecular arrangement of the tibia at the tibial tuberosity. 1. Trabeculae from the tibial tuberosity to the posterior articular surface. 2. Trabeculae from the posterior cortex to the posterior articular surface and eminentia. 3. Trabeculae from the tibial tuberosity inferior to the posterior cortex. 4. Trabeculae from the anterior cortex superior to the posterior margin of the metaphysis.

of both the femur and tibia. The epiphyseal line can be considered a laminated structure interposed between the compressive forces acting from the articular surface and the forces supporting the architecture of the metaphysis.

In 1975, Raux et al. analysed the trabecular architecture of the patella at the microscopic level and concluded that the predominant trabecular elements were the oriented sheets of hard tissue connected laterally by rods of the same structure. In the present study, the main trabeculae of the patella observed in the sagittal and horizontal sections can be said to support compression by acting on the femoral joint surface. The network seen in the frontal sections probably corresponds to the cut surface of these trabeculae. The thick and dense anterior

trabeculae support the tension of the patellar ligament

The thickness and density of the trabeculae are probably determined by the degree of compression and tension, and the trabecular orientations are probably determined by stresses Theoretically, the trabecular architecture can be thought of as a kind of rigid frame in solid mechanics The elements of this rigid frame are the trabeculae which are made of osseous tissue a kind of composite material The crossing patterns of this rigid frame are not always rectangular as described in the trajectorial theory and seem to be rectangular only where static pressure plays the predominant role It appears possible to use the finite element method of solid mechanics for examining the mechanical characteristics of the trabecular architecture

ACKNOWLEDGMENT

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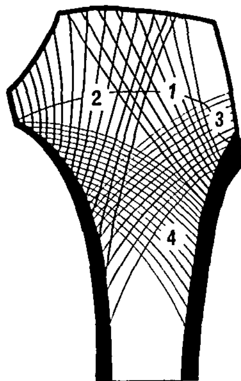


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In 1975, Raux et al analysed the trabecular architecture of the patella at the microscopic level and concluded that the predominant trabecular elements were the oriented sheets of hard tissue connected laterally by rods of the same structure In the present study, the main trabeculae of the patella observed in the sagittal and horizontal sections can be said to support compression by acting on the femoral joint surface The network seen in the frontal sections probably corresponds to the cut surface of these trabeculae The thick and dense anterior

trabeculae support the tension of the patellar ligament

The thickness and density of the trabeculae are probably determined by the degree of compression and tension, and the trabecular orientations are probably determined by stresses Theoretically, the trabecular architecture can be thought of as a kind of rigid frame in solid mechanics The elements of this rigid frame are the trabeculae which are made of osseous tissue, a kind of composite material The crossing patterns of this rigid frame are not always rectangular as described in the trajectorial theory and seem to be rectangular only where static pressure plays the predominant role It appears possible to use the finite element method of solid mechanics for examining the mechanical characteristics of the trabecular architecture

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OSTEOCHONDRITIS DISSECANS

A Histologic and Autoradiographic Study in Man

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Surgically excised cylindrical specimens from 14 adult patients with osteochondritis dissecans in the knee joint were studied with histologic and autoradiographic techniques The lesions were found to be composed of normal hyaline cartilage with no pathological changes In the bone part of the specimens there were well defined fissures at various distances from the tidemark On both sides of the fissure but especially on the OD side, there were scattered osteonecroses in complete disarray No tetracycline fluorescence activity could be seen in the lesions

Key words osteochondritis dissecans, autoradiography, fluorescent microscopy

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More than 100 years have elapsed since Sir James Paget in 1870 described osteochondritis dissecans (OD) and called it "quiet necrosis" König in 1887 first used the name OD for lesions he had seen in the human knee Since these first descriptions of the lesion, many theories have been put forward as to its etiology Several *etiologic factors, i e, trauma*, ischemia and hereditary abnormalities of ossification have been suggested

The condition has been described in animals (Reiland 1975) Here the primary disease is in the epiphyseal cartilage with secondary changes in the bone (Olsson 1976) But most authors consider that in human beings there is primarily a separation of a cartilage-bone fragment from the subchondral bone (Conway 1937, Smillie 1960, Aichroth 1971 a)

Although the long-term course of the disease has been clarified by Lindén (1976), morphological studies have so far been sparse Scintimetric studies *in vivo* (Lindén & Nilsson 1976) have *shown a very moderate, increased* radioactive uptake in the lesion No autoradiographs or fluorchromic studies of OD have been published

The purpose of the present investigation was to submit a histologic and autoradiographic study of the cartilage and the bone in OD in adults

MATERIAL AND METHODS

The series consisted of 14 patients (9 men and 5 women) aged 15 33 years (average 20 years) The patients had had symptoms of OD in the

Financial support was obtained from Svenska Läkarsällskapets fonder Ulla och Gustaf af Ugglas fond and Herman Järnhardts stiftelse

knee joints for periods ranging from 9 months to 17 years (average 4.9 years). The lesions were in situ in the medial femoral condyles in 10 knee joints. In another four joints the fragment had left the condyle.

Five days before the operation, nine patients received a peroral dose of tetracycline 1 g daily.

Two or three cylindrical biopsy specimens 2 mm in diameter were obtained at operation from the osteochondritic lesion of all the knee joints. The specimens comprised articular cartilage and subchondral bone. The biopsies were immediately placed in 10 ml of Eagles solution (37° C) containing 50 μCi ^{3}H thymidine and shaken for 3 hours. One of the sections was washed in physiologic saline solution and fixed in 10 per cent neutral buffered formalin, decalcified in 40 per cent formic acid and 20 per cent sodium citrate. The decalcified section was embedded in paraffin. Sections for histologic and autoradiographic study were prepared to a thickness of 7 μ, and stained with hematoxylin eosin, Safranin O, toluidine blue and according to van Gieson. Autoradiographs of routine histological sections 7 μ thick were prepared according to the dipping method with Ilford K2 liquid emulsion. After 3 weeks exposure the autoradiographs were developed in Gevaert X ray developer G230 and fixed in Gevaert X ray fixer G305. The sections were stained through the emulsion with Mayer's hematoxylin. The second slice was fixed in formalin, dehydrated and embedded in metylmetacrylate without decalcification. Sections 7 μ thick were cut with a bone microtome. These sections were stained with Goldner stain (Schenk 1965) and examined for osteoid tissue. One part of the second slice was left unstained for fluorescent microscopy.

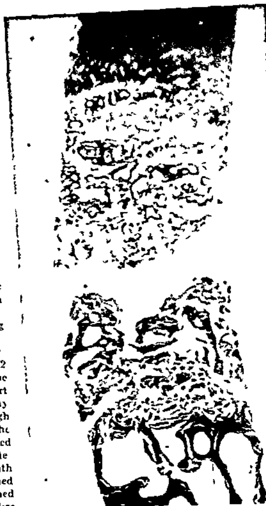


Figure 1. Surgically excised cylindric specimens from osteochondritis dissecans lesion in a knee joint. On the top the columnar and basal layer of the hyaline cartilage with a normal appearance. In the bone part a clear fissure is seen with disorganization and osteonecrosis on both sides (Goldner × 1).

RESULTS

No thymidine-labeled chondrocytes were found in the autoradiographic preparations. The number, the orientation and the appearance of the chondrocytes in the hyaline articular cartilage were within normal limits.

Hematoxylin eosin stained sections, and sections stained according to van Gieson, showed normal hyaline articular cartilage. Safranin O staining demonstrating the content of glycosaminoglycans in the cartilage varied from none at all to very deep staining in the different preparations. The nuclei of chondrocytes in the cartilage were normal as seen with toluidine-blue staining. The appearance of the hyaline articular cartilage was that of normal viable laying over an ossific nuclei. No clefts were seen. In the preparations from the four patients with empty beds the bottom was covered with fibrous cartilage of varying thickness.

In the ossific part a well-defined fis-



Figure 2 The same specimens as in Figure 1 On both sides of the fissure new mesenchymal tissue has formed (Goldner × 25)

sure was found in the bone located, in different specimens, at a varying distance from the overlying articular cartilage The fissure was situated immediately under the hyaline articular cartilage in one preparation, but in another at a distance of up to 10 mm from the tide-mark in the articular cartilage (Figure 1) On both sides of the fissure, but especially in the detached fragment there were islands of necrotic bone with disorganization of the trabeculae in the form of fragmentation, but also coarse and clumsy trabeculae Some of the lacunae were empty, but normal osteocytes could also be seen in the lacunae (Figure 2) Both osteoblastic and osteoclastic activity were observed In preparations stained according to Goldner, an increased number of osteoid seams near the fissure could be visualized on both its sides

In some preparations newly formed connective tissue, at various stages of differentiation, had begun to fill out the fissure In some, this differentiation had gone so far as to be fibrous cartilage as seen with toluidine-blue staining

Further from the fissure the bone became more normal on both sides with normal marrow and gracile trabeculae with lacunae accompanied by osteocytes No osteoid seams could be seen here

With fluorescent microscopy no tetracycline labeling was visible in the bony part of the osteochondritic lesion

DISCUSSION

Osteochondritis dissecans may be defined as a partial or complete separation of a cartilage-bone fragment from a joint with the separation of the fragment from the surrounding tissue taking place gradually (Smillie 1960)

The cause of this separation being obscure, no theory is fully accepted The hypothesis of *ischemia* postulates an interruption of the blood supply to an area of subchondral bone, which would then lead to sequestration of the bone together with the overlying articular cartilage (Riegan 1920, Axhausen 1922, Watson-Jones 1952) This interruption is supposed to be caused by emboli of fat, bacteria or red corpuscle aggregation

Some form of osteonecrosis has been postulated The osteonecrosis may appear as the result of an interrupted blood supply consequent upon traumatic squashing without fracture of the articular bone end (Roessner 1922, Jaffe 1972)

The hypothesis of *trauma* has been accepted by various authors, from the first investigation of Konig in 1887 up to the present time The trauma can be an impact of the bone by the opposing joint surface (Axhausen 1914), rotating forces (Kappis 1920), bone impression of the

patella (Hellstrom 1922), or injuries from the eminentia intercondyloidea (Fairbank 1933 Smillie 1960, Scheller 1960)

There is a certain amount of experimental support for the traumatic hypothesis (Rehbein 1950, Langenskiold 1955, Tallquist 1962, Aichroth 1971 a) Indeed, there is no clear borderline between OD and an old osteochondral fracture, although by definition the osteochondral fracture occurs momentarily in conjunction with trauma and hemarthrosis (Aichroth 1971 b)

In animals, the basic feature of OD is a disturbance of endochondral ossification The lesion is primarily located in the cartilage of the joints and the growth plate this becoming thicker than normal and dying in the deepest layers Cracks and fissures occur, and synovial fluid gets into the cracks and reaches subchondral bone causing inflammation in the joint (Olsson 1976)

In a histologic and microradiographic analysis of surgically excised lesions Chiroff & Cooke (1975) postulated that the bone of the ossific nucleus was newly formed and not merely separated from the femoral condyle by trauma

This investigation demonstrated a fissure at a varying distance from the cartilage surface a fact which could also be seen in radiograms From both sides the fissure tended to be filled out with fibrous cartilage as a sign of a reparative process but blocked by a poor blood supply to the fragment The low uptake of tetracycline and strontium 85 (Linden & Nilsson 1976) is an indication of a poor blood supply

The articular cartilage of the lesion was normal in all respects and no thymidine-labeled chondrocytes were found i e no DNA synthesis and consequently no cell division The thickness of the cartilage was normal in all preparations

It is apparent that the sequence of events is primarily in the bone in man and not in the cartilage as in animals (Olsson 1976) Aichroth (1971 a) has shown that unstable osteochondral fractures fail to unite Histologically, these ununited fragments resembled OD lesions with a viable hyaline articular cartilage lying over acellular necrotic bone On the basis of the present investigation one cannot deny that some form of trauma plays a role in the formation of OD

This investigation showed that OD in adults seems to represent some form of subchondral fracture with intact articular cartilage If the healing process is restricted the mobility of the fragment gives rise to cracks in the cartilage

In treating OD, the aim must be to improve the blood supply to the lesion, i e, to obtain connection with the medullary cavity

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Figure 2 The same specimens as in Figure 1 On both sides of the fissure new mesenchymal tissue has formed (Goldner × 25)

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THE RADIOLUCENT ZONE IN ARTHROPLASTY OF THE KNEE

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Roentgenograms of 138 knee joint arthroplasties were examined for the presence and extent of a radiolucent zone at the bone-cement interface Such a zone was significantly more common around the plastic tibial part than around the metallic femoral part of non hinged prostheses This observation argues for the theory that the development of heat plays a part in the causation of the zone In some cases a zone was demonstrable within 1 month of the operation The frequency and the sizes of such zones increased during the first 6 months after the operation There was no definite correlation between the development of a radiolucent zone and the clinical symptoms

Key words arthroplasty knee joint radiolucent zone

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The roentgenogram after total knee arthroplasty often shows a radiolucent zone at the bone-cement interface This zone does not exceed a few millimeters in width It has a well-defined limit and is sometimes surrounded by a more or less pronounced sclerotic zone in the bone It should be differentiated from the wider more diffusely limited zone, sometimes with so-called "scalloping", typical of infection The cause and the clinical significance of this zone are unknown It was therefore thought worthwhile to focus special attention on the problem in association with a review of total arthroplasty of the knee at the Department of Orthopaedic Surgery, Malmö General Hospital (Ahlberg & Lindén 1977)

MATERIAL AND METHODS

Roentgenograms of 138 knees treated with arthroplasty (16 Guépar, 82 Geomedic, 40 St Georg) during the period 1972-1975 were examined for a radiolucent zone around the femoral and/or tibial part and were classified into four groups according to the extent of the zone (Table 1 Figures 1 and 2) The roentgenograms were routine frontal and lateral views obtained at various intervals after the operation As a rule the examinations were performed immediately after operation and 1, 3 6 and 12 months post operatively The occurrence and extent of the zones were examined for any correlation with (a) the type and part of the prosthesis (b) the interval after the operation (c) the amount of cement and (d) the clinical symptoms

Table 1 Classification of zones

0 = No zone
+ = Zone occupying less than half bone ce[illegible]
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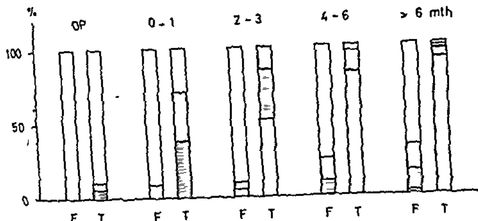


Figure 3 Radiolucent zone correlated with time after operation in Geomedic arthroplasty

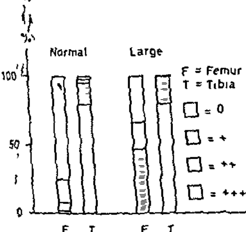


Figure 5 Radiolucent zone correlated with amount of cement in Geomedic arthroplasty

of cement was classified as large in 15 femora and 40 tibiae owing to an unnecessarily large reaming or to communication with subchondral cysts No difference in the incidence of tibial zones was found between the two groups possibly because of the relatively high frequency of zones even in tibiae with a normal amount of cement In femora with a large amount of cement zones were twice as common as otherwise (Figure 5) The difference however was not significant

(d) Of the patients who had been followed up for at least 6 months, 15 reported moderate persistent pain and six severe pain The distribution of these cases according to the various groups of zone formation did not differ from that in the entire material

DISCUSSION

The cause of the radiolucent zone is still obscure Three possibilities have been discussed, viz , mechanical injury to vessels during preparation of the bed, chemical injury caused by the monomer, and thermal injury from the heat generated by polymerisation Various model experiments favour one or the other of these theories or argue against others Thus, Jefferiss et al (1975) contend that the heat generated is unimportant while Feith (1975) claims that it is more important than the chemical and mechanical factors According to Linder (1977) the surgical preparation of the bed is more important than the monomer leakage

The most significant result of the present clinical investigation was that a radiolucent zone is the rule around the tibial but the exception around the femoral part of non hinged prostheses It is possible that part of the radiolucent zone around the femoral prosthesis remained concealed because the metal is projected over part of the bone-cement interface



Figure 1 St Georg arthroplasty Radiolucent zone femur = 0 tibia = +++



Figure 2 Geomedic arthroplasty Radiolucent zone femur = 0 tibia = ++

RESULTS

(a) The occurrence and extent of the radiolucent zones relative to the type and part of the prosthesis are given in Figure 3, which is based on the last roentgenogram in each case obtained 6 months to 4 years after the operation (14 Guepar, 68 Geomedic, 40 St Georg) The number of Guepar arthroplasties was small and no significant difference was found between the femoral and the tibial parts As for the other two types of prosthesis, radiolucent zones were almost invariably seen around the tibial part but only around one-third of the number of femoral parts This difference is highly significant

(b) The largest group of knees had been treated with a Geomedic prosthesis and this group was therefore used in the investigation of any variation of the incidence and extent of the radiolucent zones with the interval after the operation It is clear from Figure 4 that within 1 month a radiolucent zone was seen in two-thirds of the tibial prostheses and in one-tenth of the femoral prostheses The incidence and extent of the tibial zones increased rapidly from one interval to the next The corresponding increase of the femoral ones was slow

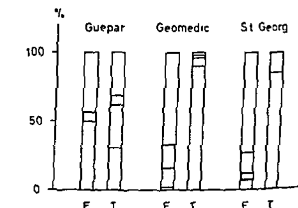


Figure 3 Radiolucent zone correlated with type and part of prostheses

(c) The zones were examined for any correlation with the amount of cement in the same group as (b) The amount

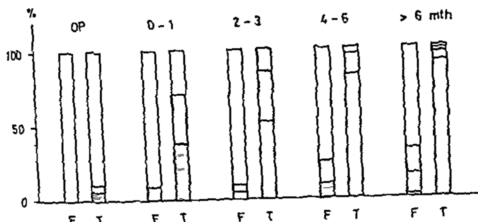
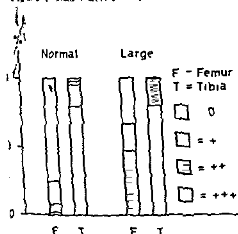


Figure 3 Radiolucent zone correlated with time after operation in Geomedic arthroplasty



gure 5 Radiolucent zone correlated with mount of cement in Geomedic arthroplasty

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The most significant result of the pres ent clinical investigation was that a ra diolucent zone is the rule around the tibial but the exception around the femoral part of non hinged prostheses It is pos sible that part of the radiolucent zone around the femoral prosthesis remained concealed because the metal is projected over part of the bone cement interface

But those parts of the bone cement interface demonstrable in the roentgenogram are sufficient to reveal any true difference between the femur and the tibia. This can hardly be explained by mechanical and vascular damage from the preparation. In both parts the preparation of the bed is the same and the cement is placed in spongious bone. Also any toxic effect of monomers should presumably be the same since Linder (1977) has shown that the cement volume is irrelevant for the monomer loss from the cement. An important difference, however, is that the *tibial prosthesis is made of* high density polyethylene and the femoral prosthesis of metal. The latter conducts and takes up heat more readily and this results in the effect of the heat being smaller around the femoral part of this form of prosthesis. In hinge prostheses, however, both the femoral and the tibial parts are made of metal, and in these cases no difference in frequency of radiolucent zones was found between the two parts. The investigation therefore appears to suggest that the generation of heat plays a role in the development of the radiolucent zones.

In about one-tenth of the tibial parts of the Geomedic prostheses, a zone was present already in the immediate postoperative films. The same observation has been made by Insall et al. (1976) in their total condylar prostheses and a probable explanation is a thin film of blood between the cement and bone. Already 1 month after the operation a zone was seen in two-thirds of our Geomedic prostheses, and this number continually increased during the first 6 months after operation. The same observation was made by Reckling et al. (1977) who believed that the reason for this was a micromotion between bone and cement. The progression of the zone, however, might also be explained by thermal necrosis with subsequent bone absorption (Slooff 1971).

The appearance of a zone is sometimes regarded as a sign of loosening of the prosthesis. One reason for this may be that both the radiolucent zone and loosening most often are localized to the tibial part. In the present material there *was no demonstrable correlation between* postoperative results or persisting clinical symptoms and the occurrence of zones.

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PERFORMANCE EVALUATION OF BK AMPUTEES THROUGH GRADED LOAD CARRYING TESTS

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The ergonomic approach to performance evaluation in orthopaedic rehabilitation presents problems because of the cumbersome and time consuming measurement and test procedures involved This paper describes a method of performance evaluation through graded load carrying tests which makes it possible to set up regression equations which can be used in routine clinical practice for prediction of the performance of below knee amputees

Key words performance evaluation regression equation ergonomic tests, biomechanical tests energy expenditure patellar tendon bearing prosthesis graded load carrying, peak heart rate, resting heart rate

Accepted 20 iv 77

The importance of an objective evaluation of a rehabilitee's performance at the terminal stage of any rehabilitation programme cannot be overemphasized In the case of a lower extremity handicap, the technique of such objective evalua tion has so far taken two basic forms (i) *ergonomic*, where the rehabilitee is asked to perform a few standard tasks or work activities during which energy expenditure and other associated cardio respiratory responses are measured and (ii) *biomechanical*, where the mechanical aspects of performance such as range of motion at joints, muscular involvement muscle power etc are studied by mechanical, electrical or electronic means or a combination of these

The ergonomic approach has an edge over the biomech… sense… the… system as a whole whereas the latter only furnishes information about one or at best a few aspects of his body mechanics However, the main disadvantage of the ergonomic method lies in the cumber some measurement techniques that are normally used, and besides, the number of tasks that the subject has to perform in order to generate worthwhile data makes it an exhausting time-consuming procedure unsuitable for routine clinical application In spite of such shortcomings, the basic superiority of the ergonomic approach must not be over looked and having realised this fact, some of the present authors have evolved a suitable test battery which can be …

… technique, came up with a series of tests for unilateral below-knee amputees using

But those parts of the bone cement interface demonstrable in the roentgenogram are sufficient to reveal any true difference between the femur and the tibia This can hardly be explained by mechanical and vascular damage from the preparation In both parts the preparation of the bed is the same and the cement is placed in spongious bone Also any toxic effect of monomers should presumably be the same since Linder (1977) has shown that the cement volume is irrelevant for the monomer loss from the cement An important difference, however, is that the tibial prosthesis is made of high density polyethylene and the femoral prosthesis of metal The latter conducts and takes up heat more readily and this results in the effect of the heat being smaller around the femoral part of this form of prosthesis In hinge prostheses, however, both the femoral and the tibial parts are made of metal, and in these cases no difference in frequency of radiolucent zones was found between the two parts The investigation therefore appears to suggest that the generation of heat plays a role in the development of the radiolucent zones

In about one-tenth of the tibial parts of the Geomedic prostheses, a zone was present already in the immediate postoperative films The same observation has been made by Insall et al (1976) in their total condylar prostheses and a probable explanation is a thin film of blood between the cement and bone Already 1 month after the operation a zone was seen in two-thirds of our Geomedic prostheses, and this number continually increased during the first 6 months after operation The same observation was made by Reckling et al (1977) who believed that the reason for this was a micromotion between bone and cement The progression of the zone, however, might also be explained by thermal necrosis with subsequent bone absorption (Slooff 1971)

The appearance of a zone is sometimes regarded as a sign of loosening of the prosthesis One reason for this may be that both the radiolucent zone and loosening most often are localized to the tibial part In the present material there was no demonstrable correlation between postoperative results or persisting clinical symptoms and the occurrence of zones

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PERFORMANCE EVALUATION OF BK AMPUTEES THROUGH GRADED LOAD CARRYING TESTS

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B N Roy & K S Bose

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The ergonomic approach to performance evaluation in orthopaedic rehabilitation presents problems because of the cumbersome and time consuming measurement and test procedures involved This paper describes a method of performance evaluation through graded load carrying tests which makes it possible to set up regression equations which can be used in routine clinical practice for prediction of the performance of below knee amputees

Key words performance evaluation regression equation ergonomic tests biomechanical tests energy expenditure patellar tendon bearing prosthesis graded load carrying peak heart rate resting heart rate

Accepted 20 iv 77

The importance of an objective evaluation of a rehabilitee s performance at the terminal stage of any rehabilitation programme cannot be overemphasized In the case of a lower extremity handicap the technique of such objective evaluation has so far taken two basic forms (i) *ergonomic* where the rehabilitee is asked to perform a few standard tasks or work activities during which energy expenditure and other associated cardio respiratory responses are measured and (ii) *biomechanical* where the mechanical aspects of performance such as range of motion at joints muscular involvement muscle power etc are studied by mechanical *electrical* or electronic means or a combination of these

The ergonomic approach has an edge over the biomechanical approach in the sense that it produces information about the performance of the patient s body system as a whole whereas the latter only furnishes information about one or at best a few aspects of his body mechanics However the main disadvantage of the ergonomic method lies in the cumbersome measurement techniques that are normally used and besides the number of tasks that the subject has to perform in order to generate worthwhile data makes it an exhausting time consuming procedure unsuitable for routine clinical application In spite of such shortcomings the basic superiority of the ergonomic approach must not be over looked and having realised this fact some of the present authors have evolved a suitable test battery which can be readily applied in the clinical setting

Ganguli et al (1973 and 1975) in their search for such a clinically acceptable technique came up with a series of tests for unilateral below knee amputees using

Table 1 Means and standard deviations of the data of control group and test group subjects

Control group (n = 6)				
	Age (years)	Height (cm)	Body weight (kg)	Body surface area (m²)
Mean	31 5	163 4	51 8	1 54
S D ±	7 4	7 7	6 7	0 13

Test group (n = 6)					
	Age (years)	Height (cm)	Body weight with prosthesis and shoe (kg)	Body weight without prosthesis and shoe (kg)	Body surface area (m²)
Mean	24 2	161 2	45 65	43 47	1 41
S D ±	4 6	4 2	5 1	4 92	0 08

patellar-tendon-bearing (PTB) prostheses The tests included four common activities of daily living and working, i e, sitting upright in a chair, standing in the erect posture, walking on level ground at a convenient speed and ascending a staircase Although otherwise quite pragmatic, the individual tasks and their respective energy expenditures had no definite relationship with each other, and therefore the method did not leave any scope for prediction of energy expenditure by extrapolation from regression curves, and each time evaluation of the performance of a new amputee was required it was necessary to repeat the whole test series

This paper describes a series of tests involving a graded exercise, where it has been possible to establish a correlation between the tasks and thus set up regression equations for prediction of energy expenditure of other comparable subjects

METHOD AND MATERIALS

The test battery included the following activities (a) sitting upright in a chair as in a sedentary type of work, (b) walking a distance of 1 km on level ground at the rate of 3 km/h this activity being a very common one for dail living and working, and (c) walking on lev ground with a shoulder pack with loads of 5 k 10 kg 15 kg and 20 kg The rate and distance of the walk was the same in the graded loa carrying tests as in the level walking test with out any load

These tests were administered to a *test grou* made up of six below knee amputees using PT prostheses and a *control group* of six matchin normal healthy able bodied subjects The mean and standard deviations of the data of the sub jects in both the groups are given in Table 1 Figure 1 shows an amputee test subject perform ing the graded load carrying test

The tests were carried out between 1000 an 1200 h in the morning and only after the whol procedure and purpose of the study had beer carefully explained to the subjects on thei arrival at the laboratory in a post absorptiv state For regulation of speed and timing ove the measured distance an investigator accom panied the subjects during the walks

During each test the parameters studied were energy expenditure (kcal/min) oxygen con sumption (l min STPD) pulmonary ventilation (l/min BTPS) and peak heart rate (beats/min) Oxygen consumption and energy expenditure were determined by collecting the expired air in a Douglas Bag and subsequently analysing it in a Haldane gas analysis apparatus The resting heart rate was recorded by timing 20 heart beats several times during the last 5 minutes of the rest period preceding the test and noting the lowest value the peak heart rate was recorded



Figure 1 A below knee amputee fitted with a PTB prosthesis and performing the graded load carrying test

similarly starting at the moment of the cessation of activity

The energy expenditure oxygen consumption and pulmonary ventilation values were expressed per unit body weight (kg) to eliminate differences between individuals as far as body build was concerned For the test group the weights of the prostheses and shoes were not considered since no energy was directly consumed by the prosthetic appliances and foot wear on the other hand the body muscles had to expend extra energy to carry these external loads

Student's *t* test was used for the various parameters to determine the differences if any between the two groups

The investigation was carried out during winter and spring when the thermal environment was generally pleasant and mild as is evident from the following data which were collected

Dry bulb range 21 0-34 0° C (mean 30 5° C)
Wet bulb range 12 0-28 0° C (mean 25 0° C)

RESULTS AND DISCUSSION

The means and standard deviations of the energy expenditure, oxygen consumptions, pulmonary ventilations and peak heart rates observed in the control as well as the test group subjects are presented in Table 2

Considering the mean values of Table 2, it was observed that while the resting energy expenditure of the below-knee amputees was around 25 per cent higher than those of the control subjects, walking without any load increased this difference markedly, the amputees expending 86 7 per cent more energy than the controls In the load carrying (5, 10, 15 and 20 kg), the below-knee amputees displayed an increase in energy expenditure of 70 per cent compared with the control group for the first three loads and 82 per cent for the heaviest load As far as oxygen consumption was concerned, the differences between the two groups were of a similar order The difference in pulmonary ventilation was 33 per cent at rest, 71 per cent for walking without any load and 53 8, 51 7, 56 9 and 65 7 for carrying loads of 5, 10, 15 and 20 kg respectively As regards peak heart rate, the increments in the test group were lower, viz 4 9 per cent at rest, 17 1 per cent for walking without any load and 16 1, 19 8, 21 2 and 22 4 per cent for walking with 5, 10, 15 and 20 kg, respectively As expected, the values for all the parameters increased as the load became heavier in both the groups

The relationships between energy expenditure (kcal/min/kg) and load carried (kg) as shown in Figure 2, can be expressed by the following equations

$y = 0.0322 + 0.0018x$ for the control group subjects ($r = +0.84$) and $y = 0.0535 + 0.0032x$ for the test group subjects ($r = +0.77$) where x and y are the load carried in kg and energy expenditure in kcal/min/kg, respectively The rise in energy expenditure with load carrying

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This paper describes a series of tests involving a graded exercise, where it has been possible to establish a correlation between the tasks and thus set up regression equations for prediction of energy expenditure of other comparable subjects

METHOD AND MATERIALS

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These tests were administered to a *test group* made up of six below knee amputees using PTB prostheses and a *control group* of six matching normal healthy able bodied subjects The means and standard deviations of the data of the subjects in both the groups are given in Table 1 Figure 1 shows an amputee test subject performing the graded load carrying test

The tests were carried out between 1000 and 1200 h in the morning and only after the whole procedure and purpose of the study had been carefully explained to the subjects on their arrival at the laboratory in a post absorptive state For regulation of speed and timing over the measured distance an investigator accompanied the subjects during the walks

During each test the parameters studied were energy expenditure (kcal min) oxygen consumption (l min STPD) *pulmonary ventilation (l/min BTPS) and peak heart rate (beats/min)* Oxygen consumption and energy expenditure *were determined by* collecting the expired air in a Douglas Bag and subsequently analysing it in a Haldane gas analysis apparatus The resting heart rate was recorded by timing 20 heart beats several times during the last 5 minutes of the rest period preceding the test and noting the lowest value the peak heart rate was recorded

parameters of the control group and the test group subjects

Test group					
Rest	Walking without load	Walking with 5 kg	Walking with 10 kg	Walking with 15 kg	Walking with 20 kg
0 020	0 056	0 069	± 0 082	0 097	0 122
± 0 004	± 0 012	± 0 013	± 0 015	± 0 019	± 0 035
0 0043	0 0122	0 0148	0 0175	0 0209	0 0262
± 0 0008	± 0 0025	± 0 0028	± 0 0031	± 0 0038	± 0 0076
0 16	0 36	0 40	0 44	0 50	0 58
± 0 08	± 0 07	± 0 06	± 0 07	± 0 08	± 0 13
76 7	93 7	102 5	110 5	117 2	128 8
± 4 5	± 4 8	± 6 6	± 10 2	± 6 7	± 17 4

administer only one of the first three load carrying tests so that the test subject has only to carry 5 kg, 10 kg or 15 kg in the shoulder pack and the value of energy expenditure so obtained may be used for cross-checking the validity of the regression equation by substituting the value of the load carried and obtaining directly the energy expenditure in kcal/min/kg This would simplify the evaluation procedure to a large extent thus making it suitable for routine clinical use From this point of view, the method described in this paper is superior to the one earlier suggested by Ganguli et al (1973, 1975) and offers much wider scope for clinical application

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Table 2 Means and standard deviations of physiological

	Control group					
	Rest	Walking without load	Walking with 5 kg	Walking with 10 kg	Walking with 15 kg	Walking with 20 kg
Energy expenditure	0 016	0 030	0 040	0 048	0 057	0 067
(kcal/min/kg)	± 0 03	± 0 008	± 0 009	± 0 007	± 0 010	± 0 012
Oxygen consumption	0 0033	0 0063	0 0086	0 0102	0 0121	0 0144
(l/min STPD/kg)	± 0 0008	± 0 0019	± 0 0018	± 0 0015	± 0 0015	± 0 0029
Pulmonary ventilation	0 12	0 21	0 26	0 29	0 32	0 35
(l/min BTPS/kg)	± 0 03	± 0 06	± 0 05	± 0 04	± 0 05	± 0 06
Peak heart rate	73 1	80 0	88 3	92 2	96 7	105 2
(beats/min)	± 6 4	± 6 8	± 9 2	± 10 8	± 10 2	± 11 7

was greater in the below-knee amputees than in the test group subjects

Interpretations based on the application of the paired *t* test for comparison between the controls and the test group subjects are as follows

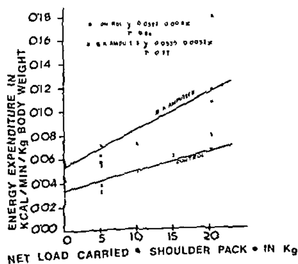


Figure 2 The relationship between energy expenditure (kcal/min/kg) and load (kg) in the control group and test group subjects

(i) *During rest, the differences* between these two groups for all the parameters studied were not significant

(ii) For walking on the level without any load, the differences in values of all parameters excepting oxygen consumption were highly significant

(iii) For all denominations of load carrying, the differences were significant for all the parameters but were of a high order in the case of energy expenditure, oxygen consumption and pulmonary ventilation and of a low order for peak heart rate

CONCLUSIONS

This investigation has shown that while the increase in the physiological effect on the below-knee amputees was much greater during level walking without any load than for load-carrying, the difference between the first three load conditions, viz, 5, 10 and 15 kg was, for all practical purposes, insignificant Taking advantage of this finding one can safely



Figure 1 Vertical fracture of the neck of the talus without displacement (Hawkins Group I) Black arrows indicate fracture



Figure 2 Vertical fracture of the neck of the talus with displacement of the body from the subtalar joint (Hawkins Group II)

advocated by Boyd & Knight (1942) and McKeever (1963). Later studies support this view (Kenwright & Taylor 1970; Hawkins 1970).

According to Kenwright & Taylor (1970) the prognosis for displaced fractures is much better when an acceptable initial reduction has been achieved.



Figure 3 Vertical fracture of the neck of the talus with displacement of the body from both the talocrural and subtalar joints (Hawkins Group III)

Avascular necrosis as a late complication can occur in about 60 per cent of cases (Hawkins 1970). Once established the treatment varies: conservative measures have been suggested by Mindell et al (1963).

Classification

Various classifications have been put forward. The most accepted is that of Hawkins (1970) which is as follows:

Group I — Vertical fracture of the neck of the talus without displacement (Figure 1)

Group II — Vertical fracture of the neck of the talus with displacement of the body from the subtalar joint but not from the talocrural joint (Figure 2)

Group III — Vertical fracture of the neck of the talus with displacement of the body from both the subtalar and talocrural joints (Figure 3)

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FRACTURE OF THE NECK OF THE TALUS

A Clinical Study

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A clinical evaluation of 46 patients treated for fractures of the neck of the talus has been made after a mean follow-up period of 6 years The cause of injury was most frequently motor vehicle accidents (26) and falls from heights (11) In non-displaced fractures plaster with immobilization was used and displaced fractures were treated by closed or open reduction At follow-up most of the patients complained of symptoms hampering daily activities Objectively, excellent to good results were obtained in 75 per cent of the non displaced fractures and in 42 per cent of the displaced Delayed union occurred in 15 per cent Avascular necrosis was found in 15 per cent and degenerative changes in 97 per cent A decreased density of bone under the articular cartilage, called subchondral atrophy, was seen in 50 per cent

Key words fractures, talus, treatment, follow up

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Fractures of the talus occur in aviation and motor vehicle accidents, in falls from heights and as a result of falling objects (Anderson 1919, Miller & Baker 1939, McKeever 1963, Coltart 1952, Mindell et al 1963, Kenwright & Taylor 1970, Hawkins 1970, Sneppen & Buhl 1974) These fractures can involve the whole of the talus with comminution and displacement or the restoration of function of the limited only to the neck of the talus In this case the fracture may be either non-displaced or displaced

The simple fracture without displacement of the neck of the talus seldom presents any problems as regards treatment or the restoration of function of the foot The displaced fracture, however, poses difficulties regarding the immediate treatment and may also impair the future function of the foot depending on whether or not avascular necrosis develops

Non-displaced fractures

The majority of these fractures are treated initially by immobilization in plaster until radiological union has been demonstrated (Miller & Baker 1939, Boyd & Knight 1942, McKeever 1963, Coltart 1952, Mindell et al 1963, Kenwright & Taylor 1970)

Avascular necrosis as a late complication has been encountered occasionally, e g , in 2 per cent as reported by Brinkmann et al (1973) Otherwise the results are reported to be excellent to good

Displaced fractures

Coltart (1952) suggested an accurate reduction by closed or open means for displaced fractures which also has been

Table 3 Type of accident causing fracture of the neck of the talus in 46 patients

Type of accident	Classification (Hawkins) I	II	III	Total accidents	
Motorcar driver	3	5	6	14	
Motorcar passenger	2	1	1	4	
Motorcycle driver	1	3	–	4	
Motorcycle passenger	1	–		1	
Pedestrian	–	2	–	2	
Bicycle		1		1	26
Fall from a height	3	6	2		11
Athletics	2	1	1		4
Falling object	1	3	1		5
Total	13	22	11		46

Table 4 Associated injuries in 25 out of 46 patients with fracture of the neck of the talus

Injury	Classification (Hawkins) I	II	III	Total injuries
Skull	1	4	1	6
Upper extremity	2	1	–	3
Same lower extremity	4	8	6	18
Other lower extremity	4	3		7
Soft tissue		2		2
Total	11	18	7	36

Table 5 Treatment in 46 patients with fracture of the neck of the talus

Treatment	Classification (Hawkins) I	II	III	Total
Non weight bearing no immobilization	–	1	–	1
Immobilization in plaster	13	3	–	16
Closed reduction + immobilization in plaster	–	8 *	6	14
Open reduction + immobilization in plaster		4	4	8
Open reduction + internal fixation + immobilization in plaster		6	1	7
Total	13	22	11	46

* percutaneous transfixation in 1 patient

Follow-up

All patients were contacted by letter and by telephone and 42 were traced of whom six could not be examined for various reasons Thus 36 patients 28 men and 8 women were included in the follow up

The period of observation varied from 1 year and 4 months to 13 years and 4 months with a mean of 6 years (Figure 5)

A questionnaire was sent to the patients and once returned the clinical examination was carried out Questions regarding various aspects of foot function pain and gait had to be answered

The patients were questioned especially with regard to possible change of work because of the foot injury the need for special shoes foot supports and walking aids The following was registered gait with special reference to limping range of motion in talocrural and subtalar joints circumference of the lower leg and around the malleolae instability of the ankle joints

All radiographs from the primary and later examinations and clinical follow up were studied Anteroposterior projections were taken of each ankle and lateral projections with a maximum of active plantar and dorsal flexion in order to detect subluxation of the ankle joint All patients were examined under non weight bearing conditions and both talocrural and subtalar joints were always examined under identical conditions

Suitable exposure data were chosen in order to be able to judge optimally the architecture of the bone trabeculae of the talus and surrounding bones A special film with a high silver content (Kodak Industrex) was of great value for this investigation

Possible displacement of subluxation of the

p ut an

attempt was made to judge the time of healing the appearance of sclerosis and also subchondral atrophy which is a new concept based on the observation that a thin zone of lessened bone density can appear under the articular cartilage

The articulations of the talus were judged by the following criteria

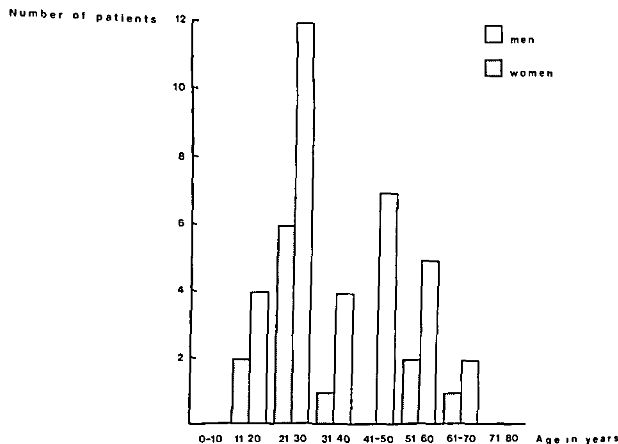


Figure 4 The distribution of age and sex at the time of injury in 46 patients with fracture of the neck of the talus

PATIENTS AND METHODS

The following clinical investigation was carried out 1) to report on a material of patients treated during the years 1960 1972 for fracture of the neck of the talus 2) to make a clinical evaluation of this material with a mean follow up time of 6 years (1 year 4 months 13 years 4 months) 3) to make a radiological assessment of late results and 4) to correlate if possible the clinical impressions with experimental observations (Peterson & Goldie 1975)

The material consisted of patients who were treated for fracture of the neck of the talus from 1 January 1960 until 31 December 1972 Forty six patients were collected

The distribution of age and sex at the time of injury is shown in Figure 4

There were four main causes of injury (Table 1) Traffic accidents falls from heights athletic accidents injury from falling objects

The classification of the fractures is seen in Table 2 and their relation to cause in Table 3

Associated injuries are presented in Table 4

The treatment is presented in Table 5 and related to the classification

Only two local complications were registered and these were wound infections

Table 1 Cause of injury in 46 patients with fracture of the neck of the talus

Injury	Men	Women	Total
Traffic	15	11	26
Fall from a height	10	1	11
Athletics	4	0	4
Falling objects	5	0	5
Total	34	12	46

Table 2 Classification according to Hawkins (1970) of 46 fractures of the neck of the talus

Sex	Classification I	II	III	Total
Men	9	18	7	34
Women	4	4	4	12
Total	13	22	11	46

Table 6 Complaints at follow-up of 36 patients in relation to the patient's general opinion of the function of the foot

	Classification						Total	
	I		II		III			
	Satis fied	Unsatis fied	Satis fied	Unsatis fied	Satis fied	Unsatis fied	Satis fied	Unsatis fied
Symptoms	4	4	8	11	5	4	17	19
Pain at rest	–	–	–	7	–	2	–	9
Pain when walking less than 2 kilometres	–	–	–	6	–	1	–	7
Pain when walking more than 2 kilometres	–	1	–	8	1	2	2	11
Not able to run normally	–	4	1	11	1	4	2	19
Pain when walking on uneven surface		4	5	11	2	4	7	19
Limping	–	–	1	5		3	1	8
Not able to do ordinary exercise	–	4	1	9	1	3	2	16
Not able to do athletics	2	4	5	11	3	4	10	19
Stiffness	–	3	1	9	1	3	2	15
Tiredness	–	–	–	4		2	–	6
Swelling	1	1	–	7	2	2	3	10

RESULTS AT FOLLOW UP

Symptoms experienced by patients in relation to subjective opinion of function

A relationship was established between the symptoms the patients experienced at follow up and their subjective opinion of the foot function (Table 6) It is evident from this table that most patients complained of symptoms which to some degree hampered their daily activities

Of the 36 patients followed up three had no work, two of them being retired and one a student Of the remaining 33 patients 26 went back to their original work after termination of the compensation period Quite a number (15) had problems with their foot at work but not to such a degree that it was incapacitating Four had sedentary work and had no trouble except that they experienced discomfort from their foot during free-time activities

Seven patients had to change occupation mainly because of pain in the fractured foot

Of the 36 patients, five needed special equipment such as Lange's foot support and heel increases

Objective clinical examination

Limping was found in nine patients

The bimalleolar circumference compared with the healthy side was increased by 1 3 cm in ten patients and, of these, five belonged to Group III

The circumference of the lower leg was decreased on the injured side by 2–3 cm in seven patients Of these, four belonged to Group III

No atrophy of the skin was noted One patient (Group II) had a slight varus and excavatus deformity of the fractured foot One patient (Group III) had a rigid equinus foot (10°) In the remaining patients the foot had a normal appearance

The range of motion is presented in Table 7

Number of patients

8

6

4

2

1 2 3 4 5 6 7 8 9 10 11 12 13 14

Years from injury to follow up

Figure 5 Period of observation at follow-up in 36 patients with fracture of the neck of the talus

A Normal appearance
B Osteophytes
C Reduced joint space including osteophytes and sclerosis In this group the type of cases included were those where the joint was disorganized by the fracture but after healing the joint space remained normal (Figures 6 a and b)
D Anchylosis



Figure 6 a Fifty year old man with Group III fracture of the neck of the talus treated with closed reduction and immobilization



Figure 6 b Same as in Figure 6 a At follow-up 13 years and 5 months after injury there is reduction of the posterior subtalar joint space and osteophyte formation

Table 6 Complaints at follow-up of 36 patients in relation to the patient's general opinion of the function of the foot

Symptoms	Classification I Satisfied 4	I Unsatisfied 4	II Satisfied 8	II Unsatisfied 11	III Satisfied 5	III Unsatisfied 4	Total Satisfied 17	Total Unsatisfied 19
Pain at rest	–	–	–	7	–	2	–	9
Pain when walking less than 2 kilometres	–	–	–	6	–	1		7
Pain when walking more than 2 kilometres	–	1	–	8	1	2	2	11
Not able to run normally	–	4	1	11	1	4	2	19
Pain when walking on uneven surface	–	4	5	11	2	4	7	19
Limping	–	–	1	5		3	1	8
Not able to do ordinary exercise	–	4	1	9	1	3	2	16
Not able to do athletics	2	4	5	11	3	4	10	19
Stiffness	–	3	1	9	1	3	2	15
Tiredness	–	–	–	4	–	2	–	6
Swelling	1	1	–	7	2	2	3	10

RESULTS AT FOLLOW UP

Symptoms experienced by patients in relation to subjective opinion of function

A relationship was established between the symptoms the patients experienced at follow up and their subjective opinion of the foot function (Table 6) It is evident from this table that most patients complained of symptoms which to some degree hampered their daily activities

Of the 36 patients followed up three had no work, two of them being retired and one a student Of the remaining 33 patients 26 went back to their original work after termination of the compensation period Quite a number (15) had problems with their foot at work but not to such a degree that it was incapacitating Four had sedentary work and had no trouble except that they experienced discomfort from their foot during free time activities

Seven patients had to change occupation mainly because of pain in the fractured foot

Of the 36 patients, five needed special equipment such as Lange's foot support and heel increases

Objective clinical examination

Limping was found in nine patients

The bimalleolar circumference compared with the healthy side was increased by 1–3 cm in ten patients and, of these, five belonged to Group III

The circumference of the lower leg was decreased on the injured side by 2–3 cm in seven patients Of these, four belonged to Group III

No atrophy of the skin was noted One patient (Group II) had a slight varus and excavatus deformity of the fractured foot One patient (Group III) had a rigid equinus foot (10°) In the remaining patients the foot had a normal appearance

The range of motion is presented in Table 7

Number of patients

8
6
4
2

1 2 3 4 5 6 7 8 9 10 11 12 13 14

Years from injury to follow up

Figure Period of observation at follow up in 36 patients with fracture of the neck of the talus

A Normal appearance
B Osteophytes
C Reduced joint space including osteophytes and sclerosis. In this group the type of cases included were those where the joint was disorganized by the fracture but after healing the joint space remained normal (Figures 6a and b).
D Ankylosis



Figure 6a Fifty year old man with Group III fracture of the neck of the talus treated with closed reduction and immobilization



Figure 6b Same as in Figure 6a. At follow-up 13 years and 4 months after injury there is reduction of the posterior subtalar joint space and osteophyte formation

Table 9 Investigator's assessment of clinical results at follow-up of 36 patients with fracture of the neck of the talus

	Classification (Hawkins) I	II	III	Total
Excellent	4	1	1	6
Good	2	5	4	11
Fair	2	6	2	10
Poor		7	2	9
Total	8	19	9	36

Excellent – Normal range of foot motion compared with healthy side
No pain at rest and none or only minor subjective symptoms
0–2 symptoms listed in Table 7

Good = 0–25 per cent restricted range of foot motion compared with healthy side No pain at rest
3 5 symptoms listed in Table 7

Fair = 26–50 per cent restricted range of foot motion compared with healthy side
6–8 symptoms listed in Table 7

Poor = > 50 per cent restricted range of foot motion compared with healthy side
9 11 symptoms listed in Table 7



Figure 7 Fifty six year-old woman with Group II fracture treated with non weight bearing for 6 weeks Tomogram (in lateral projection) shows non union 9 months after injury and sclerosis of the talar body

Damage of the anterior margin of the tibia Special attention was paid to possible damage to the anterior margin of the distal tibia Except in one case no skeletal damage was observed at the an-



a



b

Figure 8 a, b Lateral and AP views of Group II fracture of left talus 8 weeks after injury with subchondral atrophy (arrows) This atrophy cannot be seen radiologically through plaster

Table 7 Decrease in range of motion after fracture of the neck of the talus as a percentage of the range measured on the healthy side

Foot motion	Classification (Hawkins) I	II	III
Dorsal flexion	17	45	31
Plantar flexion	2	10	12
Pronation/supination	12	34	33

Only one patient experienced pain when mobility was tested and this occurred in supination, which was restricted Unloaded motion of all types was free of pain in the remaining patients

No crepitations were felt and no instability could be registered The investigator's assessment is shown in Tables 8 and 9

Table 8 Investigator's assessment of range of motion at follow-up of 36 patients with fracture of the neck of the talus

	Classification (Hawkins) *I*	*II*	*III*	Total
Excellent	4	1	1	6
Good	3	6	5	14
Fair	1	10	2	13
Poor		*2*	*1*	*3*
Total	8	19	9	36

Excellent = Normal range of foot motion compared with healthy side
Good = 0–25 per cent restricted range of foot motion compared with healthy side
Fair = 26–50 per cent restricted range of foot motion compared with healthy side
Poor = > 50 per cent restricted range of foot motion compared with healthy side

Radiologic assessment

This has been centred on evaluation of delayed union, avascular necrosis, degenerative changes, subchondral atrophy and damage to the anterior margin of the tibia

Delayed union Delayed union in this material was diagnosed when no healing was radiographically evident within 6 months There was one delayed union in Group I, four in Group II and one in Group III All these had united at the time of follow-up Clinically these patients were free from symptoms excepting one of those in Group II who had developed avascular necrosis (Figure 7)

Avascular necrosis This developed in six patients, four women and two men Three were in Group II, three in Group III Their treatment included early mobilization and weight-bearing

Degenerative changes The diagnosis of degenerative changes or osteoarthrosis was based on radiographic criteria of decreased joint space, sclerosis of juxta-articular bone and osteophytes

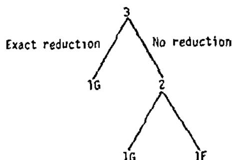
The number of patients with degenerative changes in relation to the classification of their injury was as follows

Classification	I	II	III	Total
Normal appearance	1			1
Osteophytes	5	8	7	20
Reduced joint space including osteophytes and sclerosis	2	10	2	14
Anchylosis		1		1

Subchondral atrophy During the investigation it became evident that a certain radiologic sign might have some importance in the prognostic estimation of the development of avascular necrosis Subchondral atrophy was the term used for the demonstration on X-ray films of a thin subchondral line with decreased bone density (Figure 8) This appeared after 6 8 weeks and could either be total or partial In 18 cases of Group *II* and *III* fracture this line of subchondral atrophy was total and in 17 no avascular necrosis developed

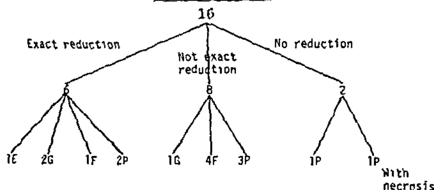
FRACTURE GROUP II WITH DISPLACEMENT ≤ 3 mm

Number of patients



FRACTURE GROUP II WITH DISPLACEMENT ≥ 3 mm

Number of patients



FRACTURE GROUP III WITH DISPLACEMENT ≥ 3 mm

Number of patients

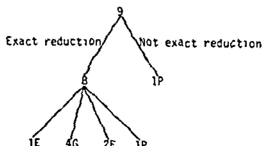


Figure 9 *Relation between the degree of reduction of Group II and III fractures and the results at follow-up E = Excellent G = Good F = Fair P = Poor*

terior tibial margin This gives support to the mechanism of injury of talar neck fractures suggested by Peterson et al (1976)

DISCUSSION

Fractures of the neck of the talus without displacement have a good prognosis but the occasional complication with avascular necrosis cannot be overlooked (Hawkins 1970, Kenwright & Taylor 1970, Brinkmann et al. 1973) Avascular necrosis is above all a radiologic diagnosis and need not yield any clinical symptoms In this material there was no evidence of avascular necrosis in the Group I fractures and the clinical results were excellent or good in six out of eight cases It appeared essential to immobilize the foot in plaster but weight-bearing seemed to have no adverse effects, provided that it was postponed until 1 month after the injury This period of non-weight-bearing seems to follow naturally after the injury because of the discomfort caused by weight-bearing during the first month

In previous studies the importance of a good reduction, either closed or open, of displaced fractures has been emphasized (Miller & Baker 1939, Boyd & Knight 1942, McKeever 1963, Collart 1952, Hawkins 1970) In this material it was obvious that an exact reduction was essential for a good result (Figure 9) Whether the reduction was closed or open did not appear to have any clinical significance, but of course the choice should be made with respect to the possibility of achieving an exact reduction and maintaining this

Avascular necrosis occurred in one patient of those treated with closed reduction (11)

One patient with avascular necrosis was treated only with non-weight-bearing for 6 weeks and the result was poor

In this investigation avascular necrosis developed less frequently in displaced fractures which were reduced by closed means, compared with those which required open reduction However, if open methods were chosen it seemed that avascular necrosis developed less frequently in those fractures which were fixed internally

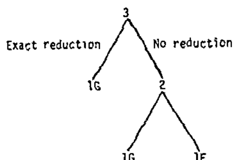
Out of 36 fractures, 28 were displaced Of these, 19 belonged to Group II and three of these developed avascular necrosis The remaining nine displaced fractures belonged to Group III and of these three developed avascular necrosis

The reason for avascular necrosis is obscure It has been said that at the moment of fracture the rupture of the arteria canalis tarsi and arteria sinus tarsi enhances the risk of avascular necrosis Support for this belief has been advanced by Marek & Schein (1945) who recorded a rate of 8 per cent avascular necrosis in triple arthrodesis

In a study of the arterial supply of the talus (Peterson et al 1974) it was possible to demonstrate that the talus is located in the centre of a vascular network, and is mainly supplied by the arteria canalis tarsi and the anastomosing arteria sinus tarsi, by the rami deltoidei from the arteria canalis tarsi and by branches from the arteria dorsalis pedis entering the neck of the talus Furthermore, the talus is supplied by small arteries in the capsules and ligaments which connect the talus with the surrounding bones The involvement of these vessels in the fracture mechanism of the neck of the talus could be demonstrated experimentally (Peterson & Goldie 1975) It was shown that in fractures without displacement the ascending branches from the arteria canalis tarsi were generally ruptured as well as the descending branches from the arteria dorsalis pedis in the fracture area With displacement of the body of the talus from the subtalar joint the arteria canalis tarsi generally ruptured, which is in accordance with

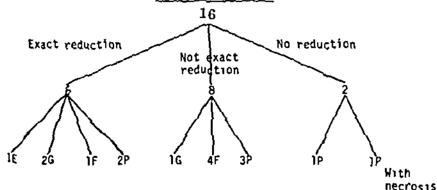
FRACTURE GROUP II WITH DISPLACEMENT < 3 mm

Number of patients



FRACTURE GROUP II WITH DISPLACEMENT > 3 mm

Number of patients



FRACTURE GROUP III WITH DISPLACEMENT > 3 mm

Number of patients

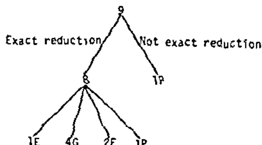


Figure 9 Relation between the degree of reduction of Group II and III fractures and the results at follow-up E = Excellent G = Good F = Fair, P = Poor

the hypothesis previously discussed by Hawkins (1970)

The clinical implication might be that the talar body can survive on the small but numerous vessels available provided that a prompt exact and stable reduction can be performed and maintained

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Acta orthop scand 48 707 711 1977

SUBTALAR DISLOCATION

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During the period from 1945 to 1972 30 cases of subtalar dislocation were reported to the Directorate of Industrial Injuries Insurance in Denmark The lesions were classified according to type of dislocation showing that the medial inward type predominated by far According to the findings of the present investigation the long term prognosis seems to be more serious than has hitherto been assumed X ray and clinical examination disclosed that arthrosis of the subtalar joints was demonstrable in 19 patients Six of these patients had pantalar arthrosis the causative factor in two cases being avascular necrosis of the talus Clinical examination showed that walking was associated with some degree of pain in 21 patients and 15 patients had a more or less pronounced limp

Key words subtalar dislocation subtalar arthrosis avascular necrosis of the talus

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Subtalar dislocation not combined with fracture of the neck of the talus is uncommon and only a few reports of the injury have appeared in the literature The first case was reported in 1811 by Judey and Dufaurest Shands (1928) who personally had only one case of this type reviewed the cases reported before 1927 and analysed 138 cases according to type of dislocation and age and sex of the patients Since then the studies have mainly been concerned with fractures of the talus and with the exception of a series of 27 cases reported by Kenwright & Taylor (1970) the series discussed have been numerically small (McKeever 1963 Mindell et al 1963 Pennal 1963 Thomasen 1943)

Great efforts have been devoted to the solution of the problems involved in the treatment and prognosis of fracture and fracture dislocation of the talus, whereas the problems involved in subtalar dislocation are considered to be comparatively small However in a series of 15 patients examined by Pennal (1963) it was found that subtalar arthrosis had developed in nine cases while Mindell et al (1963) observed two cases of avascular necrosis in a series of 10 patients We intend with this report to elucidate the mechanism of the trauma and the prognosis of the injury

PATIENTS AND METHODS

During the period from 1945 to 1972 30 cases of subtalar dislocation were reported to the Directorate of Industrial Injuries Insurance in Denmark where all employers are required to have their employees insured against accidents Quite

the hypothesis previously discussed by Hawkins (1970)

The clinical implication might be that the talar body can survive on the small but numerous vessels available provided that a prompt exact and stable reduction can be performed and maintained

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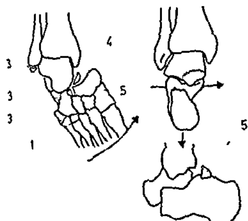


Figure 2 Type and number of associated fractures in 26 cases of medial subtalar dislocation The mechanism is illustrated



Figure 4 Medial subtalar dislocation with a typical fracture in the lateral part of the navicular bone

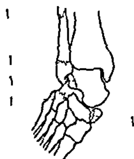


Figure 3 Type and number of associated fractures in four cases of lateral subtalar dislocation

minor subluxations persisted Both patients had medial dislocation and walked with the foot in supination

Instability One patient with medial dislocation complained of a tendency to twist the ankle in supination

Avascular necrosis of the talus Avascular necrosis occurred in two cases In one case there was a temporary increase in density but healing was complete in the other an increase in density and partial collapse of the body of the talus subsequently healed The dislocations were both of the medial type in one involving fracture of the posterior process of the talus and avulsion from the lateral malleolus and in the other being associated with fracture of the internal edge of the head of the talus and avulsion from the outer malleolus

Arthrosis Subtalar arthrosis was radiologically verified in 19 patients Six of these also had talocrural arthrosis In two of these cases the reason was avascular necrosis of the talus as mentioned above Three of the patients had compound lesions with skin necrosis superficial infection and a long immobilization period Furthermore one of them had a fracture in the lateral process of the talus This latter patient had an ipsilateral compound tibial fracture which was repaired with a plate Due to infection and prolonged healing he was not allowed weight bearing until 23 weeks after the trauma Subtalar arthrosis developed in all patients with fractures involving the subtalar joints *It was remarkable* however that subtalar arthrosis was present in 6 patients out of 13 in whom fractures had not occurred

Subjective symptoms Pain in connection with walking and a limp were the predominant symptoms at follow up Atrophy and swelling of the calf were also seen Nine patients had no complaints even with strenuous activities 16 patients had moderate complaints which were most pronounced when they were



Figure 1 Medial subtalar dislocation

naturally, a series of this type is predominated by male subjects since housewives who are not employed outside the home are not insured Thus the series comprises 29 men and one woman, averaging 39 years of age (range 15–63 years) The mechanism of injury in the 30 cases is shown in Table 1

Table 1 Mechanism of injury in 30 subtalar dislocations

Mechanism of injury	No of cases
Fall from a height	14
Weight falling on foot	8
Twisted ankle	5
Traffic accident	3
Total	30

The individual claims had to be settled within 1–2 years They were assessed on the basis of supplementary data provided by the referring practitioner and the final declarations submitted by a surgeon and a radiologist The case records applying to the subjects concerned, together with the radiographs, form the basis of the present study The period of follow up calculated from the time of trauma to the submission of the surgical opinion covered 23 months on the average (range 9–73 months)

Treatment

Most of the dislocations were easily reduced and the joints were immobilized in a below knee plaster for 8 weeks on average (range 3 23 weeks, immobilization period unknown in four cases) Open reduction was required in two cases: in one because of buttonholing of the capsule, in the other because of spiking of the lateral corner of the navicular bone into the upper medial part of the head of the talus

Initial complications

Nine of the 30 patients had sustained compound injuries, usually associated with considerable skin lesion over the prominent malleolus (Figure 1) through which the malleolus or head of the talus protruded. Skin necrosis was seen in three patients, in one of the latter skin grafting was required

Deep infection was not seen primarily, in one patient it occurred after the performance of a pantalar fusion

Classification

Dislocation of the subtalar joints involved the talo calcaneo navicular joints, i e, subtalar or peritalar dislocation The dislocation can be medial or lateral The distribution is seen in Table 2

Table 2 Type of dislocation in 30 subtalar dislocations

Type of dislocation	No of cases	
Subtalar medial dislocation		
without fractures	12	26
with fractures	14	
Subtalar lateral dislocation		
without fractures	1	4
with fractures	3	
Total		30

Medial dislocation is most common (Figure 1) and often results in two types of dislocation fractures (1) Fracture either of the lateral part of the navicular bone or of the upper medial edge of the head of the talus or both and (2) fracture of the posterior process of the talus The mechanism is illustrated in Figure 2

RESULTS

The late complications were as follows

Postural deformation In two cases

throsis The injury seems to have been more severe in the group of patients with arthrosis as compound injuries were seen in four patients, in two combined with wound infection By comparison there were only two compound injuries in the group of patients without arthrosis A comparison of the periods of immobilization is not conclusive, but no patients with arthrosis were immobilized for less than 8 weeks, this being the general treatment in the group without arthrosis Especially McKeever (1963) stresses the fact that early mobilization will prevent fibrosis and stiffness in the subtalar joints

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walking over uneven ground, nine of these patients had a slight limp Five patients had severe complaints, their activity was greatly restricted and a limp persisted A total of 21 patients complained of some pain in connection with walking and 14 patients had a limp

Eighteen of the patients were engaged in heavy work Thirteen of the 30 patients were able to resume their previous work; with certain modifications, the same applied to another eight patients, four patients had to change their work and five patients had not yet resumed work at the time when the claim was finally settled, on an average, 23 months after injury

Subtalar arthrodesis was performed on two patients and pantalar arthrodesis on two Deep infection occurred in one of the latter and the leg had to be amputated Two patients had to wear ankle-braces

DISCUSSION

The prognosis of subtalar dislocation seems to be more serious than has hitherto been assumed, primarily owing to the development of arthrosis In agreement with findings previously reported, medial dislocation was the lesion most frequently encountered in the present investigation The typical dislocation-fractures of the navicular bone and the medial edge of the head of the talus are mentioned by Watson-Jones (1962), but fractures of the posterior process of the talus have not attracted much attention The posterior talo calcaneal joint comprises the basal surface of the posterior tubercle that is facing plantar laterally This explains why fracture will occur if the calcaneum is forced medially as this will cause avulsion of the tubercle The mechanism seems obvious and, accordingly, medial distortion of the subtalar joints should be suspected in the presence of a fracture



Figure 5 Medial subtalar dislocation with typical fracture of the posterior process of the talus Avulsion of the tubercle by the dislocated calcaneum

The incidence of avascular necrosis rather surprising however, Mindell et al (1963) observed the phenomenon in two out of 10 patients Studies of the blood supply to the talus (Haliburton et al 1958, Mulfinger & Trueta 1970, Petterson et al 1974) indicate that the body of the talus is supplied mainly by the tarsal canal artery The latter may be damaged by the dislocation and, in the presence of fracture of the posterior tubercle as seen in one of our patients in whom necrosis occurred the vascularization will suffer additionally

Posteriorly a network is formed of branches from the posterior tibial artery and the peroneal artery Branches which run to the posterior process arise from this network finally to enter into the bone

From clinical experience it is known that arthrosis easily develops if fractures involve the joints Thus the high incidence of arthrosis after subtalar dislocation not combined with fracture is remarkable Six patients out of 13 without fractures in the subtalar joints had ar-

throsis The injury seems to have been more severe in the group of patients with arthrosis as compound injuries were seen in four patients in two combined with wound infection By comparison there were only two compound injuries in the group of patients without arthrosis A comparison of the periods of immobilization is not conclusive but no patients with arthrosis were immobilized for less than 8 weeks this being the general treatment in the group without arthrosis Especially Mckeever (1963) stresses the fact that early mobilization will prevent fibrosis and stiffness in the subtalar joints

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TREATMENT OF CHRONIC HAEMATOGENOUS OSTEOMYELITIS OF THE OS CALCIS

ABULFOTOOH M EID

Twenty five patients suffering from chronic haematogenous osteomyelitis of the os calcis were studied The disease often presents in a subacute or chronic form and the pathological process is well established in the majority of the cases by the time treatment is begun For this reason conservative treatment was found to be ineffective Similarly limited surgical procedures such as curettage sequestrectomy or partial excision were also inadequate because of the wide spread nature of the infection Complete excision of the os calcis and stitching of the Achilles tendon to the plantar fascia was followed by a high rate of success provided the other tarsal bones were not involved in the infective process The infection was cured and reasonably normal function was obtained in 14 out of 19 patients (73 7 per cent) A new heel is often formed after the operation by the laying down of plaques of calcification within the toughened scar tissue of the heel pad

Key words osteomyelitis os calcis

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Chronic haematogenous osteomyelitis of the os calcis is often difficult to treat (Martini et al 1974) Conservative treatment, partial excision of the os calcis and calcanectomy have been tried by different authors with varying and often conflicting results, with amputation not infrequently being the outcome (Mackay & Manes 1958)

The aim of this study was to analyse and compare the effect of the different types of treatment mentioned above

PATIENTS

This series consisted of 25 patients 17 males (68 0 per cent) and 8 females (32 0 per cent) Their ages ranged from 6 to 32 years with an average of 17 9 Radiographically the whole of the os calcis was involved in 11 patients (44 0 per cent), whereas in six (24 0 per cent) the affection was only partial (less than one third of the os calcis) The greater part of the os calcis (more than one third of the bone but not its entire bulk) was involved in eight patients (32 0 per cent) Other foci of osteomyelitis were encountered in eight patients and in six of them other tarsal bones were involved

The duration of the disease before the commencement of treatment varied from 1 week to 11 years

METHODS OF TREATMENT

All the patients were treated conservatively for periods varying from 5–32 weeks This involved antibiotic therapy supportive treatment and immobilisation when necessary Patients not responding favourably to the above regime were treated surgically

Thirteen patients with only partial and rarely extensive involvement of the os calcis underwent conservative surgery curettage in eight excision of the affected segment in seven and sequestrectomy in three Five of these patients had more than one surgical procedure each

In 19 patients the os calcis was excised com

Table 1 The various lines of treatment applied and their results, related to the age at the time of treatment, the extent of involvement of the os calcis and the duration of the disease prior to treatment

					Conservative treatment			Conservative surgery			Excision of the os calcis		
Number	Age (years)	Extent	Other tarsal bones affected	Sinuses	Duration (months)	Follow up (months)	Result	Duration (months)	Follow-up (months)	Result	Duration (months)	Follow-up (months)	Result
1	13.5	E	—	3	3	16	poor	19	11	poor	30	110	good
2	19	W	yes	1	11	22	poor				33	107	good
3	6.5	P	—	–	1/4	108	good						
4	7	E	—	2	4	17	poor	21	105	good			
5	17	E	—	1	5	32	poor	37	11	poor	48	105	good
6	27	W	—	1	61	8	poor	69	10	poor	79	92	good
7	23	W	—	3	14	6	poor	20	12	poor	32	87	poor
8	31	W	—	1	110	5	poor	115	9	poor	124	81	fair
9	9	P		–	1/3	88	good						
10	17	P	—	2	13	14	poor	27	7	poor	34	80	good
11	8	W	—	–	1	9	poor	10	9	fair	19	80	good
12	24.5	E	yes	–	39	7	poor	46	10	poor	56	77	poor
13	25	W	yes	1	30	9	poor	39	11	poor	50	73	good
14	8.5	P	—	–	1/4	71	fair						
15	21	W	yes		11	13	poor	24	5	poor	29	69	poor
16	16.5	P	—	1	5	7	poor	12	11	poor	23	65	good
17	11	P	—		1	9	poor	10	61	good			
18	6	P	—	–	1/2	58	good						
19	18	W	yes	1	17	13	poor				30	49	good
20	32	E	—	2	132	15	poor				147	34	fair
21	29	E	—	1	96	11	poor				107	29	good
22	20	W	yes	–	19	12	poor				31	24	poor
23	14	E	—	2	10	13	poor				23	19	good
24	13	W	—		14	11	poor				25	11	good
25	31	E	—	–	120	17	poor				137	8	poor

Abbreviations for extent of infective process P = partial involvement, E = extensive involvement, W = total involvement of the os calcis

pletely together with the infected soft tissues and sinuses Eleven of these patients (57.9 per cent) had previously undergone some type of conservative surgery The split heel incision (Gaenslen 1931) was used in all the cases and the tendo Achillis was stitched to the plantar aponeurosis The resulting cavity was packed with sterile gauze soaked in acriflavine Half of the pack was removed after 48 hours and the remaining part 72 hours after the operation Post-operative immobilisation in a below knee plaster-of Paris cast was maintained for 4–6 weeks with the ankle in about 10° equinus

Surgical treatment was supplemented by suitable antibiotic therapy for 2–3 weeks.

Follow-up

The follow-up period was calculated from the time the particular line of treatment was applied until the final check up if treatment was successful, or in the event of treatment failure, until another line of treatment was instituted (Table 1) This period varied from 5–108 months after conservative treatment, 5–105 months after conservative surgery and 8–110 months after calcenectomy

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TREATMENT OF CHRONIC HAEMATOGENOUS OSTEOMYELITIS OF THE OS CALCIS

ABULFOTOOH M EID

Twenty-five patients suffering from chronic haematogenous osteomyelitis of the os calcis were studied The disease often presents in a sub acute or chronic form, and the pathological process is well established in the majority of the cases by the time treatment is begun For this reason, conservative treatment was found to be ineffective Similarly, limited surgical procedures, such as curettage, sequestrectomy or partial excision, were also inadequate because of the wide-spread nature of the infection Complete excision of the os calcis and stitching of the Achilles tendon to the plantar fascia was followed by a high rate of success, provided the other tarsal bones were not involved in the infective process The infection was cured and reasonably normal function was obtained in 14 out of 19 patients (73 7 per cent) A "new heel" is often formed after the operation by the laying down of plaques of calcification within the toughened scar tissue of the heel pad

Key words osteomyelitis, os calcis

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RESULTS

In assessing the results, each important factor was given a number out of 100, viz

A) Healing of sinuses 25
B) Functional performance 35
  a) Movements of the ankle and subtalar joints, both active and passive 7
  b) Ability to stand on tiptoe 7
  c) Ability to stand on the heel 7
  d) Capacity for walking and standing 7
  e) Gait, whether the patient is limping or not 7
C) The opinion of the patient 30
  a) Pain 15
  b) Shape of the heel 5
  c) Functional capacity at work 10
D) Footwear 10

Total 100

Results were assessed as follows Good if the patient scored 75 or more, fair if he scored 50 75 and poor if he scored less than 50

Results obtained are shown in Table 1 *In patients who received proper management early in the disease process, conservative treatment yielded good results especially in younger patients* However, it can be seen from Table 2 that the best results were obtained after total excision of the os calcis

Table 2 Comparison of the results of the different lines of treatment applied

Result	Conservative treatment (25)	Conservative surgery (13)	Excision of the os calcis (19)
Good	3(12 0 %)	2(15 4 %)	12(63 2 %)
Fair	1(4 0 %)	1(7 7 %)	2(10 5 %)
Poor	21(84 0 %)	10(76 9 %)	5(26 3 %)

DISCUSSION

Antibiotics may effect a cure of haematogenous osteomyelitis only if the proper therapy is started very early in the disease process (Harsha 1964) The four patients (16 0 per cent) who responded favourably to this *regime had had the disease for only a short time prior to treatment* Osteomyelitis of the os calcis, however, often presents subacutely (Antoniou & Conner 1974, Eid & Deif 1977), thus delaying diagnosis and treatment *By then the value of antibiotics alone is doubtful* because of the resulting ischaemia and sclerosis (Buchman 1956, Trueta 1953) The os calcis, in addition, *seems to be more vulnerable to blood deprivation than other bones* It derives its blood supply from the peroneal and posterior tibial vessels via two nutrient branches (Last 1966) Its plantar surface is related to poorly vascularised fibro-fatty tissue, its medial and lateral surfaces are subcutaneous and its superior surface is articular Additional blood supply analogous to the periosteal blood vessels in other bones would be very small if any This may explain the frequency with which total and extensive involvement of the os calcis was encountered *In 4 out of 19 patients* (12 1 per cent) who underwent calcenectomy, the os calcis was found loose in a pool of pus (Figure 1) without blood supply Obviously *antibiotics alone could not be expected* to be of help in such circumstances

Conservative surgery in the form of curettage, sequestrectomy and partial excision of the os calcis has been recommended by some authors The aim was eradication of the infection and the preservation of more or less normal anatomy Results, however *were disappointing* as only two patients had good results (15 4 per cent) In a third patient, the result was rated fair, but he consented to a calcenectomy because of a persistent sinus

Figure 1 The os calcis found completely loose in pool of pus with no periosteal attachment

This made a failure rate of 84 6 per cent *Curettage* was tried in eight patients without improvement As a line of treatment of chronic bone infection this has been condemned by many authors (Mercer & Duthie 1964) It fails to eradicate all pockets of infection exposes new bone to infection and leaves behind a rigid walled uncollapsible cavity which becomes readily infected *Sequestrectomy* was tried in three patients two of them having previously had curettage A fair result was obtained in one patient who underwent calcenectomy later because of a persistent sinus *Partial excision* of the os calcis was performed in 7 patients three of them had had curettage Only two patients (28 6 per cent) achieved a good result The line of excision was arbitrarily based on preoperative radiographic appearances which did not coincide with the actual extent of the infection in the majority of the cases In many instances the line of resection had to be advanced more than once when the cut surface showed definite evidence of infection In addition the whole or most of the os calcis was involved in the majority of the cases (76 0 per cent of the series Consequently the amount of healthy bone was negligible in most of the patients

Total excision of the os calcis, together with all infected soft tissues and sinuses on the other hand was followed by a high rate of success Results were good in 63 2 per cent, fair in 10 5 per cent and poor in 26 3 per cent The procedure complies with the essential principle of treatment of chronic bone infection, i e the removal *en masse* of all infected tissues It is justified by the indolent nature of the lesion and its accompanying ischaemia the total or extensive involvement of the os calcis in the majority of the cases the ill defined nature of the lesion and the poor results obtained after less radical measures The surgical approach used in this series was the midline posterior one described by Gaenslen (1931) It was found more convenient than the lateral approach advocated by Wiltse



Figure 2 The deeply seated plantar scar after Gaenslen's approach



Figure 3 Spotty calcification after calcenectomy

et al (1959) or the modified posterior approach recommended by Martini et al (1974) Gaenslen's approach yields a deeply seated scar so that the plantar tissues form two thick cushions well adapted to weight-bearing (Figure 2), without appreciable pain In addition, it allows access to the other tarsal bones when this is necessary

Following successful calcenectomy, there often occurs spotty calcification in the heel pad This varies in extent and may amount to only small scattered plaques (Figure 3) These calcified plaques, together with the thickened and toughened scar tissue form a firm pad under the talus, thus providing a "new heel" (Figure 4). Compared with the normal side the "new heel" was shorter and broader, but the difference was slight. The height of the heel was reduced on the average by 8 mm, while its breadth was increased by 6 mm Only four patients (21.1 per cent) required a heel raise of 1 5–2 cm. Passive ankle movements showed increased dorsiflexion of an average of 6 5° compared with the healthy side. This may be due to lengthening of the tendo Achilles. This resulted in slight weakness of tiptoeing, which, however, did not materially affect the gait of these patients Only three patients complained of easy fatiguability after walking. Eversion and inversion after calcenectomy were practically the same as on the normal side Conversely, all movements were restricted following partial excision of the os calcis, possibly due to muscle spasm consequent upon persistant infection The shape of the heel and the ability to wear normal shoes were improved after calcenectomy. In three female patients the operative scar was repaired for cosmetic reasons. This minor surgical procedure gave a greatly improved result (Figure 5).



Figure 4 A well-formed new heel



Figure 5 Improved shape of the heel after plastic repair of the scar

Because of the lack of involucrum formation in the majority of the cases (Gaenslen 1931) delaying of the operation is not recommended Perseverence with conservative treatment will not prevent further bone destruction It is therefore justifiable to excise the os calcis once chronic infection is established

There were five cases of total excision (26 3 per cent) with subsequent poor results All had persistent sinuses pain and difficulty in wearing shoes Four of these patients had associated osteomyelitis of other tarsal bones The latter were not removed and thus maintained the infection Amputation has been considered the best treatment for this situation if not controlled by conservative means (Martini et al 1974) In the fifth case failure was caused by the leaving behind of a small part of the anterior end of the os calcis which was sufficient to maintain the infection

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